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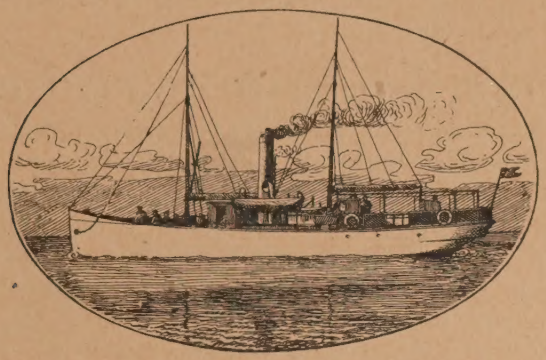
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XXVI.

1919.

By

C. G. Joh. Petersen,
Ph. D., L. L. D.
Director.

Copenhagen.
In Commission by G. E. C. Gad.
Centraltrykkeriet (C. Ferslew).
1920.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results, Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°, 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen*. Med Kort. 4°. 46 pg.

Fiskeri-Beretning for $18^{88}/_{89}$ til 1916.

Beretninger fra den danske biologiske Station findes paa dansk publiceret i de tilsvarende Fiskeri-Beretninger, til Beretning XXI med Tillæg. Senere udgives de som selvstændige Publicationer paa Dansk og paa Engelsk.

The Reports from The Danish Biological Station are also published in Danish in the corresponding Fiskeri-Beretning, until Report XXI with Appendix. Later on they are specially published in Danish and in English, but not in the Fiskeri-Beretning.

I. Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91.)*) 63 pg. Med et Kort.
II. Om vore Kutlingers *(Gobius)* Æg og Ynglemaade. (1891—92.) 9 pg. Med 2 Tavler.
II. On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pg. Two Plates.
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IV. On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pg. 2 Plates. 1 Chart. Many Tables.
V. Den alm. Aal (*Anguilla vulgaris* T.) anlægger før sin Vandring til Havet en særlig Forplantningsdragt. (1894—95.) 35 pg. Med 2 Tavler. Etc. 64 pg.
V. The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pg. With 2 Plates. Etc. 64 pg.
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VI. The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96.) 48 pg. 1 Chart. 2 Tables.
VII. Plankton-Studier i Limfjorden. (1896—97.) 23 pg. 1 Kort. 4 Tabeller.
VII. Plankton-Studies in the Limfjord. 1897. 23 pg. 1 Map. 4 Tables.
VIII. Om et Skovl-Vaad til Undersøgelse af dybere Farvande. (1897—98.) 24 pg. 10 Figurer.
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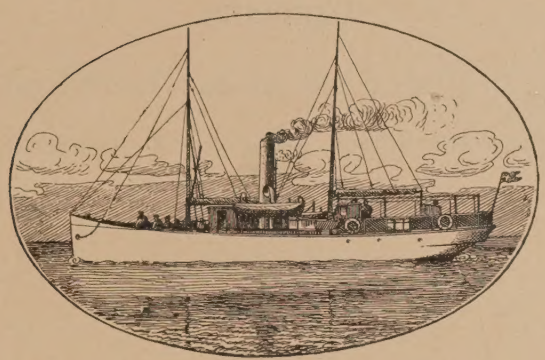

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Valuation of the Limfjord. I.

Studies on the Fish-Food in the Limfjord 1909—1917,

its Quantity, Variation and Annual Production.

By

P. Boysen Jensen.
Ph. D.

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I. Introduction.

Since the autumn of 1909 the Biological Station has performed a considerable amount of valuations in Danish waters. The Limfjord especially has been closely investigated, and within this the Thisted and Nissum Brednings, in which every year there have been made two series of valuations, respectively, in the spring and in the autumn. We are therefore already now placed before a rather complete material throwing light upon the composition of the fauna of the bottom animals, its quantity, its variation year by year and the amount of the annual production. The director, C. G. Joh. Petersén, Ph. D., has therefore thought, that now it was time to give — at any rate — a preliminary comprehension and revision of the material with regard to the above mentioned questions. This revision he has asked me to work out.

The material upon which the investigations, which will be mentioned in the following, are based, originates as said from the valuations. As to the way in which these have been made I can refer to Rep. XX of the Danish Biol. St. p. 47 ff. Only some supplementary remarks shall be added here.

The single bottom sample now as then embraces $^1/_{10}$ sq. m. When the animals have been sifted from the bottom, they are sorted, and the number of specimens within each species is counted for each single bottom sample and is put down in a table. (Examples of such special tables are found in Rep. XX.). When all bottom samples within a certain area have been taken, the total number of specimens of each single species is made up. Further the rough weight is determined; it is the weight of the animals in a humid state. Thereupon the number of specimens and the rough weight of each single species is calculated pr. 1 sq. m., these figures are put down in summary tables, a series of which will be found at the end of this paper. (Tables I, III and IV). Information is thus given by these tables about the quantitative composition of the animal bottom fauna at the time in question. The above mentioned special tables are deposited in the laboratory of the Biological Station, but for want of space they have not been added in this paper. They are of importance, if information is wanted as to whether a species is uniformly distributed over the area in question, or its appearance is local.

When the animals have been weighed, they are at first kept in alcohol. Later on they are dried. In this state all the bottom samples are preserved in the laboratory of the station except the samples from the years 1909 and 1910.

A look at the tables at the end of this paper firstly informs us, which species appear in the various localities. Yet some few of the less frequent or the species appearing in small quantities have not been put down in the lists. From a biological point of view it is now possible to divide the animals found in the bottom into two main groups, viz., producers and consumers; an account of this is given in Report XX p. 58 ff. and in Report XXII p. 73 ff. To the producers belong the animals which live on plant food in a more or less decomposed state, such as all bivalves and most of the *polychæta*. With the consumers are ranked the animals which live on animal food, viz., *Buccinum, Nassa* and *Asterias*. The other animals, *Philine, Acera, Ophioglypha* and *Echinus miliaris* take up an intermediate position between the two groups.

When in the following we are to try to account for the annual production, the rate of growth etc. of the bottom animals in the Limfjord, we must for several different reasons confine ourselves to discuss some of the animals belonging to the producers group, viz., the small bivalves and the *polychæta*. These are, however, of a rather great practical importance, because it is these animals which before all others serve as food for plaices and eels (the most important food animals in Thisted Bredning are reproduced on the plate pg. 44). As now the growth and development of the plaices besides on other conditions are dependent on the presence of nourishment in suitable quantities, these investigations besides have a further and more practical aim, namely to ascertain if the plaice fishery varies with the quantity of the plaice food at hand. A rather wide perspective has been opened up here, as may easily be seen. For in those parts of the Limfjord, where the stock of plaice either entirely or for the most part is due to transplantation, such as in Thisted, Livø and Lovns Brednings (see the map) it is possible to some extent to regulate the quantity of the stock by an increased or diminished transplantation. It must be supposed, that both a too small and a too large transplantation will prove a disadvantage; if the transplantation is too small, the bottom organisms will not be utilized in a sufficiently high degree, and if it is too large there will be too much competition for the food. Though it must not be overlooked that there are several factors which make the matter rather complicated, and then especially the fact, that the plaices are not the only fish which eat the bottom animals, it must, however, be considered certain, that when the quantity of small bivalves and *polychæta* is small, then the plaices will also grow badly. Therefore it must be said to be a task for the future to regulate the transplantation after the quantity of plaice food, which, it shall be shown, varies very much year by year.

It appears from the table for Thisted Bredning (table I), that great variations take place year by year with regard to the amount of plaice food and with regard to the species of the dominant animals. We shall only consider the animals, which

serve as plaice food. Then it may for instance be seen, that in the spring of 1914 the plaice food consists of *Solen* and *Pectinaria*, in 1915 of *Abra*, and similar variations can also be found in the other years. These variations are caused, as will be shown later on, by the fact that the small bivalves here as a rule do not live longer than a year, and that brood only appears in greater quantity at intervals of certain years*). As the breeding-years are not the same in the various bivalves, it is easily understood, that in one year we can get a *Solen* stock, in the next an *Abra* stock and so on. This circumstance is of great importance both scientifically and practically.

Scientifically it is of importance, because the various year-classes are separated by a period of time. The stock of a certain bivalve species most frequently consists only of specimens of one definite age-class, making it possible to follow each year-class during its growth and development. In this way, as we shall see in the following, it is also possible to determine with a certain approximation the amount of the production and the rate of growth in the various bivalves.

Practically it is of importance, because it may happen that one year no brood appears of any species at all, and that therefore in the following year there is no food for the plaice. This case was approximately realised in 1916, in which year in a certain part of Thisted Bredning there was only found a stock of young *Mya*. Hence in the same year, as will be mentioned later on, the plaice fishery was very bad.

The aim of this paper is therefore a twofold one, partly to study the growth and the annual production in the bottom animals, and partly to throw a light upon the connection between the quantity of plaice food and the yield of the fishery.

II. Thisted Bredning.

As mentioned above two annual valuations have been carried out in Thisted Bredning, one in the spring in April-May and one in the autumn in Sept.-Oct. In 1915, however, only two valuations were made in the midst of the summer. In every valuation after the year 1912 altogether 50 bottom samples are taken which are equally distributed over the whole Bredning. As to the position of these 50 stations the reader is referred to the map. The result of the valuations is put down in table I at the end of this paper.

As to the exactness of the valuations the reader is referred to the special tables for the first 3 valuations in Rep. XX; then 100 samples were taken. In these tables

*) A similar fact is also found in other marine animals. With regard to the herring and the cod Dr. Hjort has shown, that the breeding-years only occur at shorter or longer intervals (cf. Hjort, Fluctuations in the Great Fisheries of Northern Europe. Rapports et Procés-Verbaux, Vol. XX, Copenhagen 1914.)

calculation is made for each species of the average number of specimens at each station together with the appertinent mean error. It is seen from these calculations that the exactness of the determinations increases with the number of specimens and with the regularity of the distribution. Of *Abra*, *Solen*, *Mya*, *Nucula*, *Philine*, *Nereidæ* and *Ophioglypha* the average number is 5—15 times as great as the mean error; these figures must therefore be regarded as fairly exact; yet the error in the later years, when only 50 samples are taken, may be somewhat greater. For species with a smaller number of specimens, as for instance *Buccinum*, *Mytilus*, *Asterias* and several others, the error on the contrary is very considerable, as it may be seen from the calculations. Fortunately it is the animals of the first group which we especially have to deal with.

It is also seen from the said tables that the animals are not quite equally distributed over the Bredning. On the map in Rep. XX it is seen, that the stations 90-100 lie partly in the area of the *Zostera* region. From the tables it may be seen, that especially *Ophioglypha* is present at these stations in considerably smaller quantity than in the other part of the Bredning; but also this part is not quite homogeneous. In April 1910 (table II, Rep. XX) the eastern part of the Bredning seems to be somewhat richer than the western part. So the quantity of *Solen* and *Pectinaria* is considerably greater at the stations 70—80 than at the others. Similar facts may also be found in other years, yet it is not always the eastern part, which is the richest. Thus in 1915 there came a rich upgrowth of *Mya truncata* nearly exclusively in the western part of the Bredning. Looking over the special lists it appears, that the *polychæta* are generally distributed rather equally. The same applies, though in somewhat less degree to *Abra*, *Solen* and *Nucula*. Least regular is *Corbula*, which during the years of investigation has only appeared in three spots in the Bredning.

1. Consumption and annual production. On the basis of table I, I shall try in the following to carry out a calculation of the amount of the consumption and the annual production in Thisted Bredning with respect to the animals which serve as food for plaice and eel. It must at once be noted that these calculations cannot be very exact. Partly there are, as mentioned above, errors in the valuations, partly there appear, as may be seen below, errors in the working out of the calculations. Meanwhile through these calculations a rather thorough knowledge is gained of the appearance, conditions of growth etc. of the animals in question, so that the calculations on this account will not be worthless.

In the calculation of consumption and annual production the year is counted from one spring valuation to the next, accordingly from April to April. As to the examined bialves and *Pectinaria* the brood, as far as may be judged, only develops in the summer; yet the various species do not breed exactly at the same time; thus the brood of *Abra* often seems to appear earlier than the brood of the other species. Now in working out the calculations we can distinguish between 3 different cases.

1. The most plain case is, that all the specimens within a species belong to the same year-class. This case will occur, if in a certain year, when only very few old specimens are found, a breeding-year arises, and new brood does not appear till all the specimens from this breeding-year have disappeared. Then it is seen that the number of specimens diminishes from one spring sample to the next, at the same time as the average weight of the specimens increases.

As an example of this we may use the conditions of *Corbula* in 1911—1913. In the valuation of May 1911 no *Corbula* are found. In the same year a 0-group appears, 162 specimens*) per. 1 sq. m. (in the May sample 1912). From this 0-group there are in the April sample, 1913, 90 specimens left. In 1912 no new brood appeared.

	May 1912	April 1913
Number	162	90,4
Weight	3,9	3,4
Average weight	0,02	0,04

From the table it will be seen, that in the year 1912, counted from May 1912 to April 1913, 72 specimens have disappeared. It is presumed that at the moment of death they had a weight, whigh was the mean between the average weight in 1912 and 1913, viz. 0,03 g. The weight of the disapperared specimens has then been 2,2 g. This quantity we will call the consumption; it indicates how much has been eaten of the species in question during the year, assuming that the majority of the disappeared specimens have been eaten. It is seen that the consumption in 1912 is greater than the difference of weight between the stock in 1913 and 1912. It is caused by the fact, that the bivalves grow in the course of the year. This growth increment is calculated from the equation.

Growth increment = Consumption + Stock 1913 ÷ Stock 1912.

In this case then the growth increment is = 2,2 + 3,4 ÷ 3,9 = 1,7.

As a source of error in this calculation it must be mentioned, that perhaps it is not always specimens of the average size, which are eaten. It is possible, that the plaices and the eels are inclined to pick out the largest. I do not, however, believe, that this source of error plays any great part.

The result of the above mentioned calculation may be set up in the following way:

1912			1913
Stock	Consumption	Growth increment	Stock
Number . . 162	2,2	1,7	Number . . . 90,4
Weight . . 3,9			Weight 3,4

2. We shall now look at the somewhat more complicated case, in which we have to deal with a species, specimens of wich belong to two different year-

*) That the number of specimens is smaller in the October sample 1911 is caused by the fact, that the specimens of the 0-group at this time are so small, that some of them pass the sieves.

classes. This will be the case, if in a year, in which many old specimens of a certain year-class are present, a 0-group appears.

As an example of this we may use *Solen* in 1911—1913. In the May sample 1911 only 16 old specimens are found, which disappear during the summer. In the same year a new brood appears, 226 specimens per. 1 sq. m. From this brood there are in the April sample 1913 still 41 specimens left (see table II). Consequently it has not completely disappeared during the summer 1912. In this year new brood appears again, 62 specimens per. 1 sq. m. In the April sample 1913, therefore a mixture of specimens one and two years old, is found. The case will be as follows:

	May 1912	April 1913	
Number	226	41 old sps.	62 young sps.
Weigth	32,8	13,2	6,8
Average Weigth	0,145	0,32 *)	0,11

We then go on with the calculations in the same way as before. $226 - 41 = 185$ specimens have disappeared; their average weight at the moment of death is calculated to be $\frac{0{,}145 + 0{,}32}{2} = 0{,}23$. The consumption is then $185 \times 0{,}23 = 42{,}5$ g. The growth increment of the old bivalves is $42{,}5 + 13{,}2 - 32{,}8 = 22{,}9$ g. Furthermore 6,8 g. brood has been added. This quantity we shall indicate as upgrowth. The sum of growth increment + upgrowth we shall indicate as the annual production. In the case in question it is for the year 1912 $22{,}9 + 6{,}8 = 29{,}7$.

The result of the calculations may be set up in the following manner:

1912			1913
Stock	Consumption	Increment / Upgrowth	Stock
32,8	42,5	22,9 / 6,8	old 13,2 / young 6,8

It is seen, that it is only possible to work out the calculation of the extent of the annual production, if in the spring stock it is possible to distinguish the specimens of the 0-group from the older specimens. This will be possible in most of the bivalves with passable exactness. The criteria for this sorting are the following.

There is a rather important difference in size between the specimens of the 0-group and the older specimens. So a *Solen* of the 0-group will have an average weight of 0,14 g., a specimen one year old on the contrary 0,32 g, Similar figures are found with respect to *Abra* and *Pectinaria*. This sorting method can of course be combined with measurements. With regard to *Solen* this is done by Th. Mortensen (Vid. Medd. f. naturh. Foren. 1897 p. 321).

*) When no old specimens are left in a spring, the average weight is calculated by the curves pg. 17.

Furthermore annual rings can be found in certain bivalves. Most markedly they occur in *Corbula*. In Thisted Bredning in 1911, in which year no old *Corbula* were found, a 0-group appeared, wich can be followed all the following years till 1916. In these years hardly any new brood appeared. It can be observed, that every year a rather distinct annual ring is formed so that the age can be determined with fairly great exactness. Also at *Solen* annual rings are found; these must not, however, be confounded with the annular designs, which are often found in the shells. From these designs the annual rings are distinguished by the fact, that they go deeper into the shell as more or less marked splits. In *Abra* the annual rings are sometimes yellow. It is not necessary to add, that a close examination is to be made of the annual rings, these being often very difficult to distinguish from the above mentioned designs. According to observations in 1918 two rings can be made in one year by *Abra*; then they must not be called annual rings but growth rings.

Furthermore there is often a rather important difference between bivalves one year old and bivalves several years old with regard to the corrosion of the shells; in bivalves which have only lived one winter, the corrosion is often very slight, in older bivalves it is nearly always very prominent.

The sorting of the bivalves in the spring samples in young and older specimens has been made in the dried samples. The calculation of the rough weight of the two groups has been carried out by determination of the total weight of the sample in dried condition and the weight of the two groups of specimens, also in dried condition. These figures then are re-calculated on the total rough weight, indicated in the tables. For instance: In the April sample 1913 the *Solen* specimens were sorted into two groups. The weight of the two groups in dried condition was 1,84 and 3,56 g. pr. 1 sq. m., the total weight then 5,4g. The rough weight of the sample in question was 20 g. The rough weight of the two groups then is calculated to be $\frac{1{,}84 \times 20}{5{,}4} = 6{,}8$ and $\frac{3{,}56 \times 20}{5{,}4} = 13{,}2$ g.

When calculating the annual production and the consumption in the above mentioned manner the figures found will be a little too small. We have assumed that nothing of the 0-group is eaten before the next spring. This surely is only partly right. As to the bivalves whose brood appears late in the year, and the size of which in the first autumn is only small, the amount eaten before the spring will, I suppose, be only unimportant. But as to *Abra*, whose brood sometimes appears early in the year, it must be supposed, that the amount eaten during the autumn is not quite unimportant. In the cases, in which it can with certainty be pointed out, that a part of the specimens of the 0-group has been eaten during the winter, (viz. if the number of specimens in the 0-group is less in the spring sample than in the autum sample the previous year, for instance in *Pectinaria* 1911—1912 and 1913—1914 and in *Abra* in 1915), a correction for the consumption of the 0-group during the winter has been introduced. The size of this correction is calculated in quite the same way in which the consumption is calculated. As an example may be stated the consumption of *Pectinaria* 1913—1914.

Concerning the number of specimens and weight the following figures are found in table I:

	1913		1914
	April	Sept.	April
Number	44,6	215,2	118,4
Weigth	7,0	13,3	15,5
Average Weigth		0,06	0,13

Is is seen that the number of specimens in the Sept. sample 1913, which nearly entirely consists of brood from the same year, is 215 per. 1 sq. m.; in the next spring on the contrary only 118 specimens are found. 97 specimens accordingly have disappeared with an average weight of 0,095 g.; the total weight is then 9,2 g. This quantity must be added to the consumption for 1913, which has been calculated to 15,6 g., and to the upgrowth in 1913.

The calculation may be set up in the following way:

1913			1914
Stock	Consumption	Increment / Upgrowth	Stock
old 1,4	15,6 +	8,6	
young 5,6	9,2	15,5 + 9,2	young 15,5

3. Now it remains to deal with the case that brood appears each year. By long living bivalves there will in this case be found various year-classes in every sample. Such is the case, I suppose, in *Nucula*, which, however, is of no importance in Thisted Bredning. The calculation of the annual production is worked out in the same way as above, the point is only in the spring sample to sort the 0-group from all the older year-classes.

We may sum up the above mentioned in the following way:

By stock is understood the quantity of a certain species in the spring sample, expressed in rough weight per. 1 sq. m. By rest stock is understood the amount which is left of the stock in the following spring.

By consumption is understood the amount of a certain species eaten during a year, the year being counted from one spring sample to the next; the amount is expressed in rough weight per. 1 sq. m.

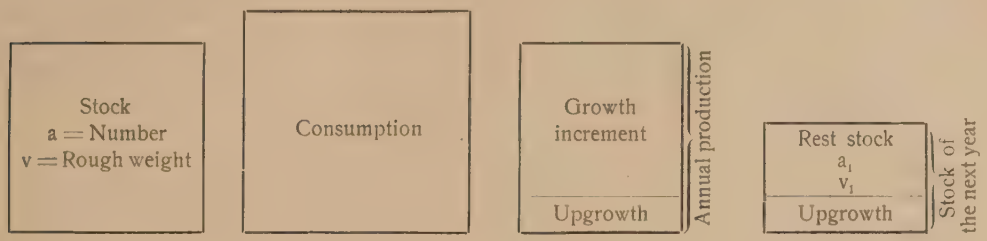
By growth increment is understood the increment of the stock in rough weight during one year, respectively to the death of the single specimens.

By upgrowth is understood the rough weight of the 0-group per. 1 sq. m.

By annual production is understood the sum of growth increment + upgrowth.

These values may graphically be expressed in the following way.

(The construction is based on the figures for *Solen* 1912—1913; the size of the squares indicate the rough weight in g. pr. 1 sq. m., see also pg. 43).



The determination of the different values is made in the following way:

The stock is found directly.

The rest stock and the upgrowth are determined directly.

$$\text{Consumption} = (a \div a_1) \times \frac{\frac{v}{a} + \frac{v_1}{a_1}}{2}.$$

Growth increment = Consumption + Rest stock ÷ Stock.

In the following we shall try to calculate the annual production in Thisted Bredning in the manner mentioned with regard to the animals which serve as food for plaices and eels. The result of these calculations has been put down in table II, to which is referred here. As to the performance of the calculations for the single species I shall remark the following:

Mya truncata. Brood in greater amount seems to occur proportionally seldom. The *Mya* specimens, found in Thisted Bredning in the years 1910—1915 are nearly all old and probably originate from 1907. This year seems to have been a very rich breeding-year. In 1910 they had grown so big that the plaices could not eat them, and therefore they could be traced all the following years, of course in somewhat decreasing amount. Not until 1915 *Mya*-brood again appeared but only in the western third of the Bredning. Yet the amount of brood in this year cannot be characterized as overwhelmingly great. In May 1916 it amounted to 20,1 g. per. 1 sq. m., calculated as the average for the whole Bredning.

Abra alba. Brood seems to appear about every second year. During the period of investigations there have been breeding-years in 1910, 1912, 1914, 1915 and 1917. In 1915 the brood appeared relatively early in the year; of the 487 specimens which were found in the June sample of the year in question, 324 belonged to the 0-group. Of these 324 specimens only 9 specimens were alive in the May sample 1916.

The calculation of consumption, growth increment and upgrowth has been made in the accustomed way for the years 1911—1913. To calculate the upgrowth

in 1914 I have estimated the *Abra* stock in April 1915 at 160 specimens, (this number was found in the September sample in 1914) having a weight of 24 g., (the average weight of the *Abra* specimens of the 0-group in the spring sample is 0,15 g). These estimated values have furthermore served for calculation of consumption and growth increment in 1915. The consumption in 1915 however, must be increased with the amount of brood, born in 1915 which has been eaten during this year, c. 300 specimens with an average weight estimated at 0,06 g., accordingly 18 g. altogether.

From *Solen pellucidus* a very numerous brood occured in 1911, at least 226 specimens per 1 sq. m. Of this generation 41 specimens were still alive in the April sample 1913. Also in 1917 a very numerous *Solen* brood appeared, about 240 specimens per. 1 sq. m. Less numerous generations appeared in 1912 and 1914. In *Solen* the sorting of the spring samples into specimens of 0-group and older specimens is not specially difficult to perform. Concerning the calculations cf. pg. 10; the calculation of the annual production in *Solen* has served as an example. In the same manner as in *Abra* I have been obliged to construct the values for the spring sample 1915; it is estimated at 60 specimens with a rough weight of 9 g.; the calculation of the consumption in 1915 is based upon this value.

Nucula nitida occurs in proportionally slight amounts in Thisted Bredning. During the period of investigations this bivalve appeared in about the same amount in the different years; as far as may be seen brood seems to occur every year and the stock, I suppose, always consists of different year-classes. Besides, the examination of this species is very difficult, because the age cannot be determined; it is not even possible to distinguish the 0-group from the older specimens with certainty. The stripes found in the shell, are scarcely annual rings. In the spring samples, however, an important difference may be observed between the greater specimens, having much more corroded shells, and smaller specimens with smooth shells; the latter are sorted off and judged as 0-group. Yet I have no proof of the correctness of this. In *Nucula* the single year-classes are not separated by time, as in the above mentioned bivalves so that we are able to follow their development. Besides the calculations have been made in the usual manner.

Corbula gibba on the contrary breeds very seldom; during the period of investigation there has been only one breeding year of any importance. While no *Corbula* are found in the bottom samples of 1910 and in the spring sample 1911, 50,4 specimens per. 1 sq. m. appear in the autumn 1911. The specimens are smooth and no annual rings are found. Hence it may be concluded with certainty that they have been born in the summer 1911. This same year-class can be traced right up to 1916. The specimens increase constantly in size year by year and at the same time the number of specimens decreases; they have rather distinct annual rings. A remarkable circumstance in *Corbula* is that the number of specimens is smaller in the autumn samples than in the spring samples, although they all belong to the same year-class. The explanation of this is probably that *Corbula* in a higher degree than the other bivalves occurs in spots in the bottom so that the

different series of samples must inevitably show a great variation. Besides, the calculation of consumption and growth increment has been made in the usual manner.

Cardium is rare in Thisted Bredning, therefore I shall omit further mentioning of it.

Pectinaria has had 2 greater breeding-years in the period of investigations, viz. in 1913 and 1917. Smaller breeding-years are found in 1911 and 1915. In contradistinction to *Corbula*, *Pectinaria* seems to be much appreciated by fishes and therefore it disappears very quickly. Like *Abra* the brood is eaten up within a year after its birth. The spring samples therefore consist almost entirely of specimens of the 0-group. The calculation of consumption and growth increment has been made in the usual way. It has however been necessary to introduce a correction in the value indicating the consumption (cf. pg. 11). A comparison between the number of specimens in the October sample 1911 and the May sample 1912 as also between the September sample 1913 and the April sample 1914 shows, that a part of the brood is eaten already during the first winter; the quantity of this consumption is calculated as usual by multiplying the number of specimens disappeared with their average weight at the moment of death.

In the other polychætes and in *Philine* and *Acera* it is quite impossible to calculate the age and the growth. I suppose that a new year-class appears every year, that the spring stock is a 0-group, and that it is eaten during the following summer. The consumption therefore has been reckoned equal to the spring stock and the upgrowth equal to the spring stock of the following year. These figures are probably too small.

Considering the sum of the different values in table II, the following results will appear.

The amount of plaice food in the years 1910—1917 in the spring samples varies from 22,8 to 60,8 g. rough weight per 1 sq. m. Specially high values are found in the years 1912—1915, viz. 44,6 and 60,8 g. per 1 sq. m. Somewhat less favorable values were found in the years 1910—1911, the food only amounting to about 22 g. As the least favorable the years 1916 and 1917 have to be considered. To be sure the amount of plaice food in these years was greater than in 1910 and 1911, viz. respectively 34,2 and 42,8 g; but of this 20 and 36 g. was *Mya* and this bivalve appeared only locally in the western part of the Bredning, while in the other part nearly no plaice food was found.

As to the consumption it must be remarked, that this value generally varies in the same manner as the spring stock; it is caused by the fact that just the spring stock makes the consumption, because for the most part it is eaten during the summer and the following winter. When the consumption is somewhat greater than the spring stock, the reason is twofold, partly the bivalves when they are eaten weigh somewhat more than in the spring, partly in some cases a portion of the brood, which possibly develops during the summer, is devoured. The consumption varies from 31,8 to 84,3.

In the years 1910—1915 the upgrowth has shown far smaller variations, than could be expected at the outset. During all these years it has been so fortunate, that every year brood has appeared either from one or another species. The extent of the upgrowth during these years has only varied between 22,9 and 65,6. In the year 1916 the upgrowth was minimal, viz. only 7,0 g. In 1917 on the contrary plenty of brood appeared both of *Abra, Solen* and *Pectinaria.* The amount of the most important food animals per $^1/_5$ sq. m. in 1911—1914 is given in the plate pg. 44.

2. Rate of growth. By the valuations it has furthermore been possible to determine how rapidly the bottom animals mentioned above grow. It is done in this manner: The average weight per specimen in samples only consisting of specimens from one definite year-class, is determined, at first in the autumn sample in the breeding-year and so on in the following years, as long as the series in question can be traced. The result of the investigations have been the following:

Abra alba.

	First year		Second year	
	Sept.-Oct.		April-May	Aug.-Sept.
1910	0,13	1911.....	0,19	
1912	0,09	1913.....	0,10	0,30
1914	0,06	1915.....		0,27
Mean...	0,09		0,15	0,29

Solen pellucidus.

	First year	Second year		Third year
	1911	1912		1913
	Oct.	May	Oct.	April
Weight pr. specimen ...	0,09	0,15	0,23*)	0,32*)

Th. Mortensen has examined the rate of growth in *Solen* in Sallingsund by aid of the measuring method (Vid. Medd. f. naturh. Foren. i Kbhvn. 1897 pg. 321). June 30th, 1896 he made a dredging in Sallingsund and measured all the *Solen* specimens he found. It turned out that 3 well distinguished groups of length were found, the first, the 0-group having a length of c. 2 mm., the next group having a length of 13—17 mm. and the third group having a length of 23—28 mm. This agrees very well with the results obtained in Thisted Bredning, where the length of the *Solen* specimens one year old in May 1912 was 15—20 mm. and the length of the specimens two years old in 1913 was c. 25 mm.

Corbula gibba.

	First year	Second year		Third year		Fourth year	
	1911	1912		1913		1914	
	Oct.	May	Oct.	Apr.	Sept.	Apr.	Sept.
Weight pr. specimen ...	0,03	0,02	0,05	0,04	0,05	0,06	0,08

*) These two samples consist of specimens from 1911 and 1912, but the stated average weight will apply to the specimens from 1911.

Pectinaria koreni.

	First year Sept.-Oct.		Second year April-May
1911.....	0,15	1912	0,21
1913.....	0,06	1914	0,13
Mean...	0,11		0,17

Mya truncata.

The rate of growth of the year-class 1907:

	1910		1911		1912		1913		1914	
	Apr.	Oct.	May	Oct.	May	Oct.	Apr.	Sept.	Apr.	Sept.
Weight pr. specimen	8,2	10,3	12,6	13,5	15,1	14,4	16,3	17,0	19,5	14,0

Nucula nitida.

As to this bivalve it is not possible to determine the rate of growth.

The figures mentioned above have been plotted in the curves (Fig. 1 and 2).

It appears from the curves, that the rate of growth is about the same in *Abra, Solen* and *Pectinaria,* while on the contrary *Corbula* grows very slowly. The figures in question will only apply to Thisted Bredning, and they will no doubt vary very much year by year, even within this limited area. For instance it appears from the tables, that in *Abra* the average weight of the specimens in the 0-group in Sept.—Oct. may vary from 0,06—0,13.

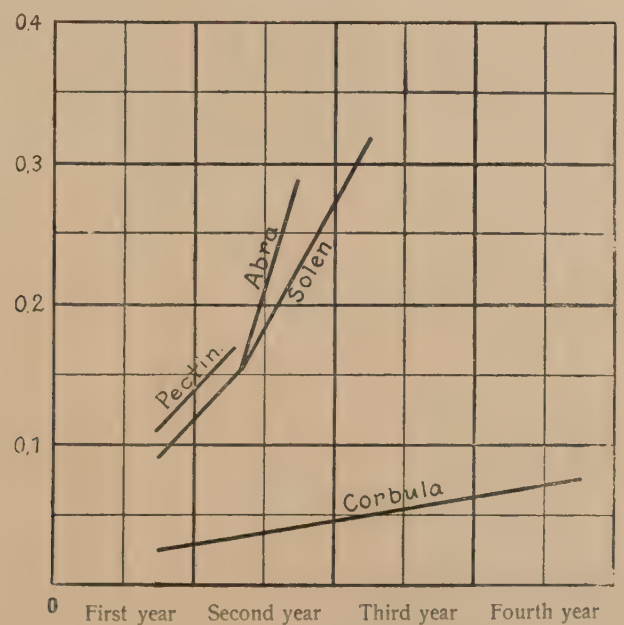


Fig. 1. Rate of growth at *Abra, Solen, Corbula* and *Pectinaria.*

3. Stock of Bivalves and Stomach Content of Plaices.

It was mentioned above, that these investigations also have a practical aim; namely, to throw light on the connection between the plaice fishery and the

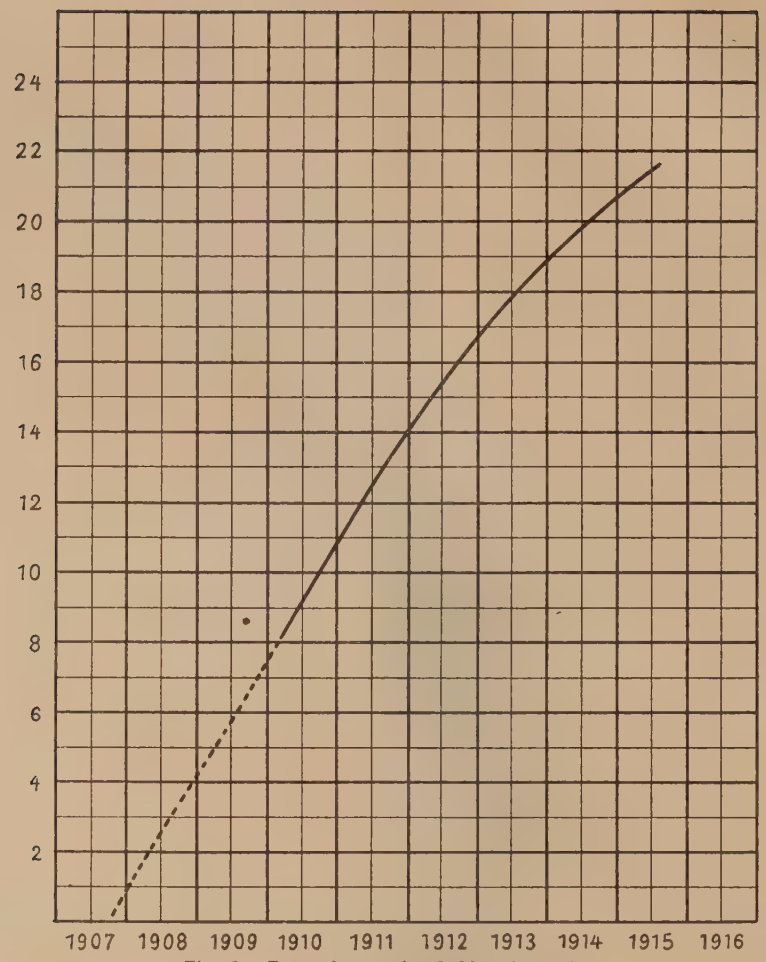


Fig. 2. Rate of growth of *Mya truncata*.

amount of plaice food. It was also said, that just the animals, whose annual production has been discussed above, make the essential food of plaice and eel. This will be discussed in this section.

The question of the food of plaice and eel has been discussed in Rep. of the D. Biol. Stat. XXIV in a paper by H. Blegvad: About the Fish Food in the Danish Waters within the Skaw. On the basis of the investigations of the station we shall give a more detailed account with regard to Thisted Bredning.

To elucidate the question mentioned above it is of course necessary to make investigations at the same time of the composition and amount of the bottom fauna and of the stomach content of the plaices. A method to examine the stomach content quantitatively has been worked out by cand. mag. Blegvad in the paper mentioned above.

In table 1 are tabularized the amount of bottom animals in the spring valuations in rough weight per 1 sq. m., though only with regard to the species

which are found in plaice stomachs in a fairly considerable amount. The table is an extract of table I at the end of this paper. When the rough weight of an animal surpasses 10 g. per 1 sq. m., the figure is underlined, hence it may easily be seen from the table which animals dominate in the different years.

Table 1. The amount of plaice food in the spring samples in Thisted Bredning. Rough weight pr. 1 sq. m.

	1910	1911	1912	1913	1914	1915	1916	1917
Abra alba	0	9,3	0	6,0	2,0	44,2	1,2	0
Solen pellucidus	4,6	4,0	32,8	20,0	11,6	3,9	2,1	0,4
Mya truncata (juv.)	0	1,5	1,2	0,7	0,9	0,9	20,1	36,0
Corbula gibba	0	0	3,9	3,4	3,4	3,2	1,6	0,1
Nucula nitida	3,6	1,6	7,1	5,3	4,8	4,7	3,1	1,9
Philine, Acera	0,8	1,9	2,2	2,2	1,5	—	—	0,1
Pectinaria koreni	7,0	3,2	12,2	7,0	15,5	0,4	5,6	0,8
Polychætes	3,3	2,1	4,6	3,4	5,4	2,9	4,5	2,4

Table 2. Comparison between the animals dominating in the bottom samples and the stomach content of plaices.

	Dominating animals	Stomach content of plaices.
1910		
1911	*(Abra)*	*Abra, (Solen)*
1912	*Solen, Pectinaria, (Nucula)*	*Solen, (Polychætes), (Pectinaria)*
1913	*Solen, (Abra), (Pectinaria), (Nucula)*	*Solen*
1914	*Pectinaria, Solen*	*Solen, Corbula*
1915	*Abra*	*Abra*
1916	*Mya, (Pectinaria)*	

The dominating animals are put down in table 2. In this table also the animals, whose rough weights lie between 5 and 10, have been given parenthetically. Furthermore it is indicated, which animals were found in the plaice stomachs at the same time as the valuations were made. The parenthesis shows that the animals in question have been found in a smaller amount. Besides the stated animals also a few others have been found in quite small amounts, as for instance *Nucula, Cardium, Philine, Acera* and *Mya truncata.* Yet this latter species was the principal food of the plaices in 1909. Very seldom *Ophioglypha texturata* and *Asterias rubens* may be found.

From the facts mentioned above we can conclude the following:

1. In Thisted Bredning the principal food of the plaice is *Abra, Solen, Mya, Pectinaria* and other polychætes, in a lesser degree *Corbula, Nucula, Cardium, Philine* and *Acera.*

2. The animals dominating quantitatively among the bottom animals are as a rule also predominant in the plaice stomach.

This latter fact, however, does certainly not hold good in every case. The species mentioned above have scarcely all the same value as food animals, and when food is at hand in sufficiency, the plaices will make a choice. Thus *Corbula* seems not to be much appreciated. It can be seen, that a certain year-class of *Corbula* may keep living through several years without being eaten. As said above it is possible to trace the brood of *Corbula* from 1911 to 1916. On the contrary it is seen that the brood of *Abra, Solen* or *Pectinaria* for the most part is eaten up already in the following summer; these three animals are certainly excellent food animals. For what reason *Corbula* is not appreciated by the plaices it is not easy to say. Partly these animals are rather small, partly they are very thick-shelled. Perhaps also the byssus of *Corbula* is unagreeable to the plaices. In localities where for want of other food they are obliged to eat *Corbula* in greater quantity, the peculiar phenomenon appears called ring-flounders, because they have a ring, which goes through mouth and gill-opening consisting of byssus threads of *Corbula* rolled together.

All the above mentioned animals never grow so big that the plaices are not able to eat them. On the contrary *Mya truncata,* which as said above in certain years is an important food animal can only be eaten in the first years of their life. In Thisted Bredning an exceedingly rich stock of young *Mya* was found in the years 1908—1909, and at the same time the stomach content of the plaices consisted almost exclusively of this bivalve. The plaices, however, were not able to eat up the whole stock in these years, and after that time the *Mya* specimens had grown so big, that the plaices could not eat them. These old *Mya* have therefore been living in Thisted Bredning till now, but the number of specimens has diminished a little year by year. In the stomach content of eels, however, siphons of big *Mya* are sometimes found bitten off, and in the bottom samples *Mya* specimens with abrupted siphons have also been found. Of course these *Mya* will die in the course of time. It seems that the plaices are able to eat *Mya* up to a length of 3 cm.

4. Stock of Bivalves and Fishery Statistics. In the preceeding chapter we saw that the food of the plaice consists of the small bivalves living in the bottom especially *Abra* and *Solen* together with *Pectinaria.* The next question will then be if any connection can be found between the amount of food animal and the yield of the plaice fishery.

It is not given at the outset, that such a connection exists. It were possible, that so great an excess of plaice food was at hand that even in the poorest years there was plenty of food for the plaices. But seeing how rapidly the different

year-classes of for instance *Abra* are eaten, it does not seam that there is any excess of food. The calculations in Rep. of the Dan. Biol. St. XX p. 60 ff. and XXV p. 35 ff. concerning the ratio between the amount of plaice food, seem to point in quite the same direction. It is therefore very reasonable to believe that the amount of fish food usually found in the Bredning will not surpass the consumption and that a considerable decrease will also cause a descent in the rate of growth of the plaice and thus also in the yield of the plaice fishery.

There are, however, various facts to be taken into consideration.

Firstly it is only the part of Thisted Bredning lying outside the 6 m. curve, the bottom fauna of which we examine by the valuations. This part only amounts to 6533 ha. while the area of the whole Thisted Bredning amounts to 9647 ha. The part of the Bredning, not examined, thus makes about $^1/_3$ of the whole area, and therefore it is just possible that in the not examined part of the Bredning so much fish food might be at hand, as would be enough to cover the consumption of the plaices even if the food found in the other part of the Bredning was inconsiderable. A reliable valuation of this marginal zone it has not, unfortunately, been possible to make, on account of the condition of the bottom. It is however, quite improbable that the marginal zone, for a great part covered with *Zostera*, should be much richer than the rest of the Bredning; the Stations 45—50, lying within the *Zostera* area, are at any rate not; at all events it will certainly only be the plaices, living in the neighbourhood of the marginal zone, which may profit by the animal life in this zone, but not the plaices living farther off in the Bredning.

Furthermore it must be emphazised, that not only the plaices and eels, but also a series of other animals, especially *Asterias*, *Buccinum* and *Ophioglypha*, eat the small bivalves. A rather great competition for the food therefore probably takes place. So it is not given beforehand, that the amount of food which is left for the plaices, is proportional to the quantity of food found in the Bredning, because the possibility must be taken into consideration that the amount of the predatory animals, competing with the plaices for the food, may vary year by year. As to the extent of the variations within the predatory animals the tables unfortunately do not give reliable information, because these animals are so rare that the valuation of them cannot be made with sufficient exactness. Generally the predatory animals no doubt live several years, therefore it is scarcely likely that the yearly fluctuations are very great. Besides the number of predatory animals seems to be decreasing.

Further it is unfortunate, that no quite exact statistics of the plaice fishery in Thisted Bredning can be produced (see table 3). About this Dr. Petersen communicates the following:

„For administrative reasons, the statistics are finished 31' Dec., thus comprising a calendar year; it would be better if it were reckoned from 1' April to 1' April next year, viz. from one transplantation to the following; but as a rule during the months January—March there is not much fishing, so that this source of error is not considerable as there are so many others; as in all fishery statistics collected

voluntarily the exactness is not very great. I shall here specially mention the item of the consumption of the fishermen and the retail trade outside the towns. The given figures must therefore be used with much caution.

The years 1909 and 1910 may, however, be considered as specially good years with regard to the captured quantity of plaice. In these two years 30 plaices pr. ha. were transplanted, in 1908 only 20 and in previous years still fewer. 1911 shows a great decrease compared with the two preceeding years. The Bredning has never again reached these two good years 1909 and 1910 with regard to profit. 1916 has even been much poorer than any preceeding year. In 1917 no plaices were transplanted for want of petroleum and therefore several regulations for preserving the fishes were abolished. In 1917 in May, June and July comparatively many small plaices were fished up, being left from the preceeding year or years; the few still left in Oct.–Nov.–Dec. reached a very considerable size, partly because of their small number, partly on account of the abundance of food grown up during the year and the thriving of which was also, perhaps, connected with the fewness of the plaices. 1917 was the very worst year since 1908, as was expected.

Table 3. Statistics of transplantation and fishery of plaices in Thisted and Visby Bredning from 1908 to 1917.

According to the fishermen's union of Thisted.

	Transplanted into Thisted- and Visby Bredning		kg caught in Thisted Bredning	kg caught in Visby Bredning
	No of sp.	kg		
1908	372,320	c. 29,785	69,250	32,500
1909	c. 550,000	c. 44,000	90,000	59,000
1910	"	"	94,050	48,000
1911	"	"	53,750	31,450
1912	c. 688,900	c. 55,100	61,600	39,000
1913	"	"	55,881	31,700
1914	"	"	61,122	38,133
1915	"	"	53,750	47,900
1916	"	"	29,551	22,770
1917	0	0	14,913	12,490

The consumption of the fishermen is not included in this table.
The average weight of the transplanted plaices is reckoned 8,0 kg pr. 100 sp.

It is an obvious conclusion that the reason for the great decrease in 1916 is the want of nourishment on the bottom. The great fishery in 1909 is coincident with a rather great amount of youg *Mya* in Thisted Bredning. In 1910 and 1911 the spring stock was generally rather small; but during the summer in 1910 numerous *Abra* brood and in 1911 *Solen* brood appeared. As mentioned above 1912–1915 were rather favourable as to the amount of plaice food, but in 1916 only a very local stock of young *Mya* was found in the western part of the Bred-

ning, whereas the amount of plaice food in the other part was very small. Nor did any brood appear during the summer.

These valuation investigations are so recent, that care must be taken to avoid too rapid conclusions; they have always caused us several surprises and promise a glimpse into the economy of these waters which it is certainly worth deepen, not only in view of these waters, but also of the general importance which these investigations will seem to obtain for the judgment of the productivity of other salt waters."

III. Nissum Bredning.

Also in Nissum Bredning two annual valuations were carried out nearly at the same time as in Thisted Bredning. At each valuation 40 bottom samples were taken, distributed over the area of the Bredning lying outside the 6 m. curve. Some few of the samples, however, lie within this curve. The position of the stations is marked out in the chart. The result of the valuations is put down in table III at the end of this paper.

When looking at the chart of Nissum Bredning in Rep. XX, we see that the marginal zone, i. e., the part of the Bredning lying within the 6 m. curve is of far larger extension in Nissum than in Thisted Bredning. The calculations of areas stated in Rep. VI. pg. 32 show, that the marginal zone in Thisted Bredning amounts to 32 percent of the total area. In Nissum Bredning the marginal zone amounts to 47 percent even if the part lying within the 2 m. curve, which in part lies dry at low water, is not included. Of the 40 stations, the 7, viz., no. 13—15 and no. 26—29 lie within the 6 m. curve, while the other are outside.

The animals put down in the summary table are far from equally distributed over the whole Bredning. A survey of the special tables shows that the stations lying within the 6 m. curve, viz., the stations 13—15 and 26—29, have a bottom fauna somewhat different from the other stations. Already from the special tables, given in Rep. XX. this fact appears. It may be seen from the table from April 26th, 1910 that, of 121 *Abra alba*, 118 are found upon the stations 13—15 and 26—29. Of 23 *Macoma baltica* 15 are found upon the same 7 stations. Upon the whole the bottom animals seem to be distributed in the same way as in the other years.

From this it appears, that presumably it will be necessary to attach a certain biological importance to the 6 m. curve in Nissum Bredning. Within this curve all the animals put down in the summary table except *Corbula* are found, but outside the curve *Abra* and *Macoma baltica* are very rare.

It appears therefore, that it would no doubt be correct to divide the 40 bottom samples, taken in Nissum Bredning into 2 groups, the first one referring

to the part of the Bredning lying between the 2 and the 6 m. curve and comprising the stations 13—15 and 26—29, and the other including all the other bottom samples and referring tho the part of the Bredning lying outside the 6 m. curve; but then it is necessary to make new calculations for the rough weight per 1 sq. m., because the quantities put down in the summary tables account for the samples in their entirety.

Such calculations I have carried out as to the food animals in the following way. From the special tables I have computed how many specimens of each species are found on the 7 stations mentioned above and how many on the others. Assuming that the average size of the specimens was the same in the two localities, I have from these figures and the total rough weight calculated the rough weight in the two localities and from this again the rough weight per 1 sq. m. for the marginal zone and the other part of the Bredning. These figures are put down in the table 4 pg. 24.

Table 4. Fish food in the spring valuations in Nissum Bredning, rough weight per 1 sq. m. in g.

1. Within the 6 m curve (= less depth than 6 m).

	1911	1912	1913	1914	1915	1916	1917
Abra alba		0,7	21,8	3,4	1,3	0,3	1,3
Abra nitida.....	0,4	6,0	2,0	—	3,6	—	0,2
Solen pellucidus.	0,1	0,3	0,3	0,1	—	—	0,3
Nucula nitida...	38,0	99,0	86,0	81,0	39,0	15,3	25,4
Corbula gibba ..	4,2	6,4	—	0,3	7,9	1,1	7,6
Macoma baltica.	28,5	20,8	11,7	13,6	5,9	5,2	14,2
Pectinaria koreni	0,4	—	4,0	0,6	—	—	0
Polychætes.....	4,2	5,6	1,8	6,9	2,9	2,0	4,6
	75,8	138,8	127,6	105,9	60,6	23,9	53,6

2. Outside the 6 m curve (= deeper than 6 m).

	1911	1912	1913	1914	1915	1916	1917
Abra alba.....		0,2	3,7	2,8	0,2	—	0,8
Abra nitida	0,9	0,2	3,9	0,4	0,3	—	0,6
Solen pellucidus.	0,4	0,6	0,5	1,2	0,1	0,2	0,1
Nucula nitida ..	26,7	37,5	34,4	24,4	12,2	7,7	7,4
Corbula gibba ..	1,3	11,3	3,7	10,0	100,0	81,2	66,5
Macoma baltica.	0,8	0,3	0,2	0,2	0,2	0,9	0,4
Pectinaria koreni	2,0	1,1	5,4	2,8	—	0,5	0,5
Polychætes.....	2,6	3,9	3,9	11,4	2,0	1,7	4.6
	34,7	55,1	55,7	53,2	115,1	92,2	80,9

As to the exactness of the valuations there will no doubt be a rather great difference between the two groups of figures. In the part lying outside the 6 m.

curve 33 stations have been taken; though the distance between them is of course greater than in Thisted Bredning on account of the great area, the error in the determinations of the rough weight is scarcely greater. The most important of the animals found there, seem to judge from the special tables to be distributed rather equally over the area. It is otherwise with the part lying within the 6 m. curve. The 7 stations within the 6 m. curve are far from giving any reliable idea of the amount of animal food in this part of the Bredning and the figures at hand must therefore be used with reservation. When no more samples have been taken, the reason is partly that on account of the low depth of the water it is very difficult to take bottom samples within the marginal zone.

1. The Composition of the Bottom Fauna. As seen in the summary table it is upon the whole the same species of bottom animals, which are found both in Thisted and Nissum Bredning. In both localities bivalves belonging to the *Abra* community make the bulk of the bottom animals. A closer examination, however, shows that rather characteristic differences are found between the two Brednings especially with regard to the predominating animals.

Firstly the amount of the great bivalves, *Ostrea*, *Mytilus* and *Mya truncata* is very small in Nissum Bredning. They are found so seldom in the bottom samples, that we have not been able to mention them in the summary table. This fact I shall not go further into here as it has been discussed elsewhere (see Rep. XXV).

But also with regard to the small bivalves Nissum Bredning is somewhat different from Thisted Bredning. In the latter Bredning *Abra*, *Solen* and *Pectinaria* were the predominating animals; but outside the 6 m. curve in Nissum Bredning it is *Nucula* and in later years also *Corbula*. On the other hand *Abra* and *Solen* are rarely found and relatively few *Pectinaria*. The bottom animals in this part of the Bredning belong to the *Abra* community.

Within the marginal zone a bivalve is added, which is very seldom found in the examined part of Thisted Bredning, viz. *Macoma baltica*. The 6 m. curve seems to be coincident with the limit for the occurrence of this bivalve; this curve therefore to a certain degree forms a community limit, *Macoma baltica* being one of the typical members of the *Macoma* community. The 7 stations, however, are probably to be considered as a transition between the two communities, as also animals from the *Abra* community, especially *Nucula*, are found here in important amounts.

Thus the bottom fauna in Nissum Bredning consists outside the 6 m. curve of bivalves belonging to the *Abra* community with *Nucula* and *Corbula* as the most prominent members; whithin the 6 m. curve we gradually pass over to the *Macoma* community.

2. The amount of plaice-food in Nissum Bredning. As the valuations in Nissum Bredning, as shown above, are not so exact as in Thisted Bred-

ning, especially not with regard to the marginal zone, a calculation of the annual production, though possible to carry out, will be so full of errors that its value would be rather problematic. Furthermore, it is far from having as great practical and scientific interest as the annual production in Thisted Bredning. For these reasons such a calculation has not been carried out, and in the following I shall only mention some facts which appear from the tables.

As to the amount of plaice food it is seen in table 4 pg. 24 that it varies very much, in the marginal zone from 24—139 g. and in the remaining part from 35—115 g. rough weight per 1 sq. m. In the marginal zone the amount of food has been decreasing in later years, because the amount of *Nucula* has been reduced, in the deeper part it has on the contrary been increasing, because *Corbula*, which is found nearly entirely in this part of the Bredning in later years has been increasing very much. On an average there has been 84 g. in the years 1911—1917 in the marginal zone, in the remaining part 69 g. of fish food in rough weight per 1 sq. m.

From this it appears, that the amount of fish food in Nissum Bredning is considerably greater than in Thisted Bredning, where the average rough weight per 1 sq. m. in the years 1910—1917 was only 41 g. From this it must not, however, be concluded that Nissum Bredning is „better" than Thisted Bredning. As mentioned above also the quality of the food is of great importance, and in this respect the matter stands thus, that the bivalves, composing the bulk of the food in Nissum Bredning, viz. *Nucula* and *Corbula* are very thickshelled and therefore have a rather small content of organic dry matter. For these or other reasons they seem to be devoured in very small degree by the plaices. On the contrary the good food animals, *Abra, Solen* and *Pectinaria* occur rather rarely in Nissum Bredning.

Add to this the fact, that Nissum Bredning is very overpopulated with plaices. As mentioned in Rep. XVIII, 1909, the number of plaices for unity of area is 40—60 times greater in Nissum Bredning than in Thisted Bredning. It is therefore easily understood that the competition for the food must be rather great in Nissum Bredning, which fact also appears rather plainly from the valuation investigations.

For from the summary tables it is seen, that the 0-group of the good food animals already disappears in a great degree during the first winter, evidently because it is eaten up. As to *Pectinaria* for instance the following quantities per 1 sq. m. is found:

1911		1912		1913
May	Oct.	May	Septb.	April
5,5	53,3	2,8	105,8	19,5

Both in 1911 and 1912 a rather numerous brood has appeared, as may be seen from the autumn samples in the years in question; — in the spring samples of the following years the quantity has decreased to respectively $^1/_{19}$ and $^1/_5$ of the quantity in the autumn samples in the preceeding year. The same will apply

to *Solen* and in certain years also to *Abra*. On the contrary it will in a much lesser degree apply to *Nucula* and not at all to *Corbula*.

As to the importance, appearance and occurence of the different food animals I submit the following.

Abra alba appears rather seldom in the valued part of Nissum Bredning. Within the 6 m. curve there has on the contrary been rather abundant brood in 1912 and 1913, as seen from the autumn valuations for the years in question. The largest part of the brood has been devoured during the first winter in both cases.

Solen pellucidus occurs very sparingly in Nissum Bredning. Especially in 1915–1916 it has only been present in a quite minimal amount. The brood seems to appear rather frequently, thus in the years 1910–1913 each year, but the brood is not numerous and it is very quickly devoured.

Nucula nitida composes together with *Corbula* the majority of the fish food in Nissum Bredning, so that the two bivalves are supplementals to each other. In the years 1910–1913, as *Corbula* was present in rather small amount, *Nucula* was found in important and rather constant amounts, but in the later years it seems to be somewhat decreasing, at the same time as *Corbula* has been increasing. This, however, must be considered as accidental. *Nucula* occurs in the whole Bredning, but is found in somewhat greater amounts at the stations in the marginal zone than outside this zone. Like in Thisted Bredning brood seems to appear every year.

Corbula gibba. Also in Nissum Bredning *Corbula* seems to breed rather seldom. In the year 1911, when very abundant brood appeared in Thisted Bredning some brood also seems to have appeared in Nissum Bredning, but is has been of very little importance. In Nissum Bredning there seems only to have been one breeding-year of greater importance, viz. 1913. The valuation lists, it is true, show a much greater number of *Corbula* in 1914 and 1915 than in the autumn of 1913; but the explanation of this is, I suppose, that in the first year they go through the sieves in great numbers on account of their small size. The *Corbula* specimens in the autumn samples 1913 seem, at least for the most part, to originate from 1913. *Corbula* is almost exclusively found outside the 6 m. curve. It does not seem to be much pursued.

Macoma baltica as mentioned above only occurs within the 6 m. curve and here it is of much more importance than can be supposed from the summary tables. Probably also this species breeds rather seldom. A great breeding-year occurred in 1913. It is highly esteemed eemed by plaices, and it is therefore very remarkable, that it seems able to grow several, perhaps 3–4 years old; it might be expected, that the brood would be eaten up rapidly. The annual rings are rather distinct.

Pectinaria koreni has been of rather great importance as a source of nourishment in the years 1911 and 1912, but not in the remaining years. In the years mentioned a rather important brood was found. This fact will not be evident before consulting the autumn samples; as mentioned above *Pectinaria* is very

rapidly eaten up; and consequently its number in the spring samples is often unimportant. *Pectinaria* is moustly found outside the 6 m. curve.

This latter will also apply to the other polychætes. Their amounts are about the same as in Thisted Bredning. Only in a single year viz., 1914 they have been of some importance.

Philine aperta is rather seldom found and *Acera bullata* does not occur at all in the lists from Nissum Bredning.

3. The rate of growth in Nissum Bredning. As distinct from what is the case in Thisted Bredning the rate of growth of the bottom animals in Nissum Bredning is very difficult to calculate, because in some cases they are eaten up before they grow old, in others because the valuations are not sufficiently exact. There is an animal, however, whose growth can be calculated with sufficient exactness, viz. *Echinocardium cordatum*, and therefore this animal has been included here, although it does not belong to the food animals (See also C. G. Joh. Petersen, Fluctuations in the annual numbers of certain Invertebrata in J. Hjort, Fluctuations in the Great Fisheries of Northern Europe. Rapports et Procès-verbaux, Vol. XX, 1914).

In 1912, when scarcely any old Echinocardies were found, numerous brood appeared, whose rate of growth can be traced until 1915. During this time no new brood has appeared.

	1912	1913		1914		1915	
	Sept.	April	Sept.	April	Sept.	June	Aug.
Number	41,5	60,0	32,8	43,3	19,8	13,7	7
Weight	29,9	100,0	242,5	321,0	142,3	145	88
Weight per specimen	0,72	1,67	7,4	7,4.	7,2	10,6	12,6

The figures are, as will be seen, somewhat irregular; especially it will be noted that the number is greater in April 1914 than in the autumn of 1913. Also the weight per specimen is somewhat varying; the information, however, is gained that even rather great Echinocardies, weighing 10—12 g., are not more than 3 years old. The rate of growth in *Echinocardium* is put down in the subjoined curve, fig. 3:

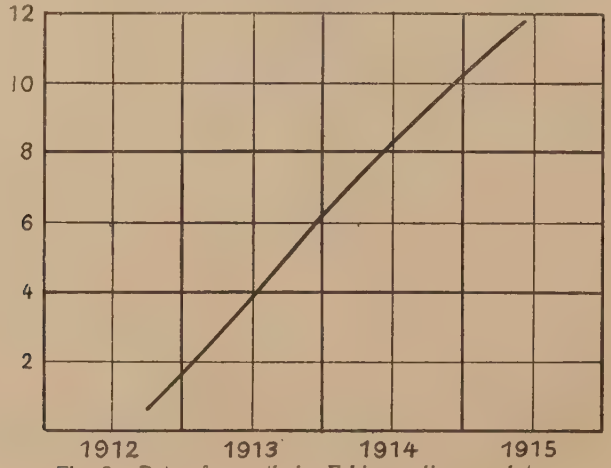


Fig. 3. Rate of growth in *Echinocardium cordatum.*

4. Stock of bivalves and stomach content of plaices. Investigations of the stomach content of plaices has also been made in Nissum Bredning in the same manner as in Thisted Bredning in order to compare its composition with the bottom fauna.

However, all the plaices, whose stomach content has been examined, have been caught in a rather limited part of Nissum Bredning, namely on or at the Fjordgrund or at Helligsø brick-field. Both these localities are lying in the north-western part of the Bredning within the 6 m. curve. Their stomach content must therefore be compared with the bottom fauna found on the stations lying within this curve; it is not certain, however, that the Fjordgrund has quite the same bottom fauna as the stations mentioned.

The composition of the bottom fauna is mentioned pg. 24 in table 4. In the subjoined table 5 is stated, which animals have predominated during the different years. The parenthesis indicate that the rough weight of the animals in question was between 5 and 10 g.; in the animals without parenthesis it has been more than 10 g. Besides it is indicated, which animals have been found in the stomachs of plaices during the spring, the same time in which the valuations have been worked out. The succession in which the animals are put down in the table corresponds to the amount in which they have been found in the stomach content; the animals which have been of greatest importance are put down to the left. The plaices examined in 1915 have been caught far out at Thyborøn and cannot therefore be compared with the others.

Tab. 5. Comparison between the animals predominating in the bottom samples and the content of the plaice stomachs.

	Predominating animals	Content of plaice stomachs in the spring valuations
1911	*Nucula, Macoma*	*Macoma, Pectinaria*
1912	*Nucula, Macoma, (Corbula), (Abra nit.), (Polychætes)*	*Macoma, Nucula*
1913	*Nucula, Abra, Macoma*	*Abra, Macoma, Polychætes*
1914	*Nucula, Macoma, (Polychætes)*	*Polychætes, Abra, Macoma*
1915	*Nucula, (Corbula), (Macoma)*	*[Corbula]*
1916	*Nucula, (Macoma)*	not examined

A comparison between stomach content and bottom fauna shows, that it is mainly the same species, which are found in stomach content and in bottom. *Macoma* is very prominent as food animal; *Nucula* on the contrary is found in very unimportant amounts in the stomach content. It is possible, however, that this bivalve does not occur in larger quantities at the shallowest parts in the bottom.

IV. The remaining Brednings of the Limfjord.

In the remaining parts of the Limfjord valuations have also been made, which, however, have not been worked out as systematically as in Thisted and Nissum Brednings. The result has been put down in table IV. In the following a short summary of these valuations will be given; firstly I shall mention the continuous series of Brednings connecting Nissum Bredning with the channel from Løgstør to Aalborg, viz., besides Nissum Bredning, Lavbjerg Bredning, Kaas Bredning, Sallingsund and Livø Bredning; then I shall deal with the neighbouring Brednings originating from these Brednings, viz. the water round Venø, the water west and north of Mors (with the sections Næs Sund-Jegindø, Visby Bredning and Thisted Bredning) and finally the Brednings originating from Livø Bredning (Risgaards Bredning, Lovns Bredning and Skive Fjord). As done above under the mentioning of Nissum and Thisted Brednings, only the animals serving as food for eels and plaices have been taken into consideration.

1. **Nissum Bredning** has been fully dealt with above. The marginal zone belongs to the *Macoma* community, the deeper parts on the contrary to the *Abra* community represented by a *Nucula-Corbula-Pectinaria*-association. *Abra* and especially *Solen* are of rather subordinate importance in this part of the Bredning. Compared with the other parts of the Limfjord the amount of *Nucula* is rather great, in the years 1910—1914 ca. 30—50 g. per 1 sq. m., during the later years much smaller; *Corbula* first appears in greater amounts from 1913, ca. 60—100 g. per 1 sq. m.

2. **Lavbjerg Bredning** has been investigated in 1910, 1912, 1915, 1916 and the spring of 1917. During the last 3 years this Bredning has been united with the southern part of Kaas Bredning; 5 samples have been taken. Lavbjerg Bredning together with Kaas Bredning and Sallingsund seem to form a transition between Nissum Bredning and Livø Bredning. Thus *Nucula* is here found in a considerably smaller amount than in Nissum Bredning, at most with a weight of 13—16 g. per 1 sq. m. At the same time *Abra* and *Solen* are found in somewhat greater amount, although here too they are of only slight importance; the first named appeared especially in 1916 with 19 g. per 1 sq. m., the last named in 1910 with 8 g. per 1 sq. m. *Corbula,* however, is also here the predominating animal; but its appearance is not quite coincident with its appearance in Nissum Bredning. In the last named place almost all the specimens as mentioned above originate from 1913; in Lavbjerg Bredning there have besides this breeding-year also been breeding-years probably in 1909 and again in 1914. The amount of *Corbula* is rather great, ca. 100 g. and more per 1 sq. m. *Pectinaria* and polychætes are found here as everywhere in the Limfjord in varying, sometimes rather important amounts.

3. Kaas Bredning and **Sallingsund** are very much like Lavbjerg Bredning. As to *Nucula* and *Corbula*, the above mentioned will apply also to these waters; in later years, however, *Corbula* is found here in still greater amount; in 1915 and 1916 there have been 250 to 375 g. *Corbula* per 1 sq. m A conception of their number will best be attained, if we calculate that on a square with a side length of 10 cm. between 20 and 25 specimens are found. In 1917 the amount has decreased considerably to 35—100 g per 1 sq. m. As in Lavbjerg Bredning *Corbula* has been breeding both in 1909 (?), 1913 and 1914. *Abra* is found in varying, often not quite unimportant amounts, 10—15 g. per 1 sq. m. In 1910 *Solen* was the predominating bivalve in Kaas Bredning and was then found in much greater quantities than in any other place, the waters round Venø excepted; viz., ca. 150 g. per 1 sq. m. In the following year it was only present in a rather small quantity, but in 1917 it again appeared in great amounts, ca. 170 g. per 1 sq. m. *Acera bullata* appeared in Sept. 1913 with an amount of ca. 40 g. per 1 sq. m. which likewise is more than ever found elsewhere. In the other years, however, it has not been more common in Kaas Bredning than elsewhere.

4. In Livø Bredning the bottom fauna is formed by a typical *Abra* community, represented by an *Abra-Solen-Pectinaria*-association. The 3 species appear in varying amounts. *Nucula* is of very inconsiderable importance; its quantity does not amount to 10 g. per 1 sq. m. Nor does *Corbula* appear in greater amounts; in 1913 there were ca. 80 g. per 1 sq. m., the other years there have only been 20—25 g. or less. As a whole Livø Bredning is very similar to Thisted Bredning, with the difference, however, that *Mya truncata* is of less importance in Livø than in Thisted Bredning.

5. The waters round Venø are nearly related to Livø Bredning in respect to the composition of the bottom fauna. *Nucula* and *Corbula* are of rather minimal importance; especially *Nucula* is sparingly represented, and the amount of *Corbula* is also rather small (20—30 g. per 1 sq. m) at any rate compared with the neighbouring Lavbjerg Bredning. The predominating animals were, especially in earlier years, *Abra*, *Solen* and *Pectinaria*. The great amounts of *Solen*, which were found in 1910 in Kaas Bredning, we find again in the waters round Venø. The amount here was even somewhat greater, viz., 189 g. per 1 sq. m. *Abra* is of considerable importance in 1910 and 1913, and is found in not insignificant amounts in 1916. *Pectinaria* occurs with similar amounts as elsewhere in the Limfjord.

6. Næs Sund-Jegindø has a very poor bottom fauna. *Abra* is the bivalve occuring in the greatest amount; but this too is very sparingly represented.

7. Visby Bredning has only been valued in 1915, 1916 and the spring of 1917. For this reason only little can be said about its bottom fauna; but to judge

from the samples at hand it seems to be rather closely related to that of Thisted Bredning. As in the last mentioned Bredning, *Mya truncata* seems also to be at hand in Visby Bredning in rather abundant amount.

8. Thisted Bredning has been discussed thoroughly above. Here we shall therefore only mention that it is nearly related to Livø Bredning in respect to its bottom fauna. Both the mentioned Brednings have *Abra-Solen-Pectinaria* as predominating animals. The difference between the two Brednings is, that in Thisted Bredning *Mya truncata* occurs in rather great amount; this bivalve has had 2 breeding-years, viz., 1907 and 1915.

9. Fur Sund-Risgaards Bredning in all respects has almost the same bottom fauna as Livø Bredning; *Mya truncata*, however, seems to be of a somewhat greater importance than in this Bredning.

10. Skive Fjord. The bottom samples put down in table IV under Skive Fjord all lie in the outmost (northernmost) half of the fiord as seen from the map. They are a continuation of the stations in Risgaards Bredning, and the composition of the bottom fauna is also about the same in this part of Skive Fjord as in the Bredning mentioned.

11. Lovns Bredning, which forms a side Bredning to the outmost part of Skive Fjord, has a bottom fauna of a similar composition as in Thisted Bredning; on an average it is probably somewhat poorer, and most likely it must be named as a transition between the *Abra* and the *Macoma* community. Likewise as in Thisted Bredning there is found in Lovns Bredning *Mya truncata* in rather abundant amount besides *Abra*, *Solen* and *Pectinaria*. The numerous brood of *Mya truncata* found in 1915 in the western part of Thisted Bredning reappears in Lovns Bredning but is not found in Livø Bredning lying between. The most essential difference between Thisted and Lovns Brednings is that in the last mentioned Bredning a bivalve is found which we have not met with before, viz., *Mya arenaria*. The appearance of this bivalve indicates that we have gone so far inside, that the *Abra* community is passing over into the *Macoma* community. In Lovns Bredning fewer echinoderms, too, are found than in Thisted Bredning.

12. Summary. In the deeper parts of the Brednings of the western Limfjord the bottom fauna is composed of animals belonging to the *Abra* community. The most important of these (besides the predatory forms) are *Abra alba*, *Solen pellucidus*, *Mya truncata*, *Corbula gibba*, *Nucula nitida* and *Pectinaria koreni* and other polychætes. Rather great differences may, however, be pointed out between the different Brednings with regard to the composition of the bottom fauna. As the investigations as yet only comprehend a relatively short period, and as it has appeared that the bottom fauna in a certain Bredning also varies much year by year, it is

of course necessary to be very cautious in laying too much stress on the difference mentioned between the Brednings; but the investigations at any rate indicate, that the *Abra* community in the Limfjord may be divided into 3 or 4 subsections with fairly precise geographical limits. These subsections may perhaps be called associations, by which is understood subsections of communities with distinct faunistical composition. Thus it will perhaps be possible to distinguish between the following associations.

1. A *Nucula-Corbula*-association, characterised too by its nearly total want of *Solen*. This association is found purest in Nissum Bredning, where the *Nucula* amount for a series of years has been ca. 30—50 g. per 1 sq. m.; during the last years it has decreased a little, yet only to ca. 10 g. In the other Brednings an amount of *Nucula* exceeding 10 g. only appears as an exception. *Corbula* which is found in great amounts in Nissum Bredning together with *Nucula* is probably in much smaller degree a characteristic animal; it is for instance still found in rather important amounts in Skive Fjord. In the *Nucula-Corbula*-association *Abra* is only found in smaller amounts, *Solen* is rare and *Mya truncata* is not found at all. That *Abra* and *Solen* appear in so small amounts in Nissum Bredning is probably caused by the fact that they are specially persecuted by the plaices.

2. An *Abra-Solen*-association, where *Nucula* and generally also *Corbula* are of subordinate importance. This association is most typically found in Livø Bredning. As mentioned above the two bivalves are found in very fluctuating amounts in the various years.

In Lavbjerg and Kaas Brednings transitions between the *Nucula-Corbula* and *Abra-Solen*-associations are found.

3. An *Abra-Solen-Mya truncata*-association, found in the side-Brednings originating from Livø-Løgstør Bredning, respectively Thisted-Visby Brednings and Risgaards and Lovns Brednings. This association has the same composition as the *Abra-Solen* association and is only different from this by the occurrence of *Mya truncata*.

When entering into shallow water or in the very inmost Brednings this association is displaced by the *Macoma baltica* formation. One of the characteristic animals of this formation, *Mya arenaria* is found together with animals of the *Abra-Solen-Mya truncata*-association in Lovns Bredning as mentioned above.

V. An experimental Investigation of the magnitude of the Production.

Besides by calculating the production as done above by valuation, this value can also be directly found by examining how many bottom animals are growing up during a certain period upon an area where no bottom animals at all were found at the beginning of the experiment. Such experiments have been made by the Biological Station in Nykøbing, Mors, in a basin, belonging to the oyster company, and which has been placed at disposal for these experiments in 1911 and 1912 from May to Sept. At suitable intervals the basin was supplied with new water by pumping. With this water plankton organisms as for instance gastropod- and bivalve larvae were led into the basin, where they fix themselves and form the bottom fauna whose composition and amount is determined in the experiment. The temperature of the water in the basin was about the same as in the water outside.

In 1911 a qualitative investigation of the upgrowth in the basin was made. On June 26th the basin only contained some large oysters. On August 30th it was drained. At that date there was found in the basin a bottom fauna of the following composition:

Bivalves: *Ostrea edulis* (a few specimens, 20—30 mm), *Mytilus edulis* (many, 30 mm), *Cardium edule* (many, 20 mm), *Cardum exiguum* (many, 7 mm), *Tapes pullastra* (many, 12 mm), *Corbula gibba* (a few, 7 mm), *Modiolaria marmorata* (many, 5 mm), *Solen pellucidus* (a few, 5 mm), *Mya sp.* (tolerably many, 16 mm), *Mactra subtruncata* (a few, 7 mm).

Gastropods: *Æolis* (16 mm), *Nassa reticulata* (3 mm), *Acera bullata* (many, 15 mm), *Cerithium reticulatum* (many, 3 mm), *Hydrobia ulvae* (4 mm), *Rissoa membranacea* (4—5 mm), *Littorina littorea* and *inconspicua* (2 mm).

Polychætes: 1 *Nereis* (100 mm).

Crustacea: *Gammarus* (many, 10—13 mm), *Idothea* (many, 13 mm), *Carcinus maenas* (1 specimen, 13 mm).

Echinoderms: *Asterias* (1 specimen, 30 mm).

Actiniae (10 specimens, 30 mm).

Ascidia: *Ciona canina* (40 mm), *Botryllus* (many), *Clavellina* (tolerably many), *Phallusia* (tolerably many).

During the following year 1912 a quantitative determination of the upgrowth in the basin was made with the assistance of mag. scient. Grøntved. On July 2nd there was only found upon the bottom a layer of detritus with numerous hydroid colonies, but no bivalves and gastropods. Already at the end of the same month, July 27th, numerous brood of different bottom animals were found. The amount and composition of this bottom fauna was determined per 1 sq. m., and this determination was repeated later on, August 26th. Shortly after the basin was used by the oyster company and the experiment could not be continued. The result of the two valuations is set down in the subjoined table.

The Quantity of bottom animals in the oyster basins in gr. rough weight per 1 sq. m. 1912.

(A. = Number, V. = Rough weight.)

		$^{27}/_{7}$ 12	$^{26}/_{8}$ 12
Mytilus edulis	A.	840	940
	V.	19,1	38,4
Mya arenaria	A.	52	56
	V.	1,3	2,8
Cardium edule	A.	360	410
	V.	21,6	51,0
Nassa reticulata	A.	61	130
	V.	0,5	7,4
Acera bullata	A.	13	16
	V.	0,2	1,2
Cerithium reticulatum	A.	c. 100	250
	V.	–	0,4
Rissoa sp.	A.	597	145
	V.	3,6	1,6
Altogether...		46,3	102,8

Firstly as to the composition of the bottom fauna, it consists, as will be seen from the tables, especially of animals belonging to the *Macoma* community. Yet in 1911, 5 bivalves appear which do not come under this, viz., *Ostrea, Corbula* and *Solen,* belonging to the *Abra* community, and *Tapes* and *Mactra,* which more particularly belong to the *Venus* community.

Next, as to the magnitude of the production, it will be seen, that a very important amount has grown up in 1912 during the two months of experiment. As seen from the table, the rough weight at the end of August was 103 g. per 1 sq.m. As further appears from the tables, this great quantity originates from 2 bivalves, viz., *Mytilus* and *Cardium,* which have evidently found very favorable growth conditions. Why they are so favorable to these bivalves it is not easy to say. Yet a single fact shall be pointed out, possibly of some importance, to wit the fact that no predatory forms destructive to the young brood are found in the basins.

VI. Breeding-Years in the Limfjord.

One of the most obvious peculiarities in the valuation tables is, that even neighbouring Brednings in the same year may show great differences as to the composition of the *Abra* community; in other words, that the different Brednings

do not go together. As the bottom animals here in question, as shown above, do not generally live more than a year, this may arise from the fact that the brood of various bivalves in certain cases has a very local appearance. This fact very interesting in both practical and scientifical respect, has been very closely investigated. Basing on the summary tables and the valuation samples kept in the Biological Station I have tried to make up in which years the single species mentioned above have been breeding in the different Brednings. It is evident, that this estimation is only passably reliable in the case of Thisted and Nissum Brednings while the fragmentary valuations of the other Brednings only make it possible to carry through the investigation of these Brednings for single years.

The results of these investigations have been put down in table V. The figures in the tables give the number of specimens of the 0-group per 1 sq. m. Sometimes the number of brood is deduced from the autumn sample of the year in question; in certain cases, f. i. in that of *Corbula*, which have distinct annual rings, the breeding-year can be determined even in specimens several years old. When two different samples have given different numbers of brood for the same year, I have chosen the superior number. On the whole it will apply that the figures must be regarded as minimum figures; at the time when the specimens are so big that they are retained by the sieves, a portion of them have already been devoured. For this and other reasons too much importance must not be attached to the absolute value of the figures. My aim is only to show the variation in the quantity of brood year by year, and for this they may, I think, be used. An indication of the position of the breeding-years by + and ÷, which I tried to work out at first, cannot be given, as good and bad breeding-years without limits merge into each other.

From the table it seems to appear that the animals which have been examined may be divided into 3 groups according to the frequency of the brood appearance. The first group comprises the animals breeding every year, the second group comprises the animals breeding frequently, but yet not every year, and the third group finally comprises the animals breeding very seldom.

To the first group only one bivalve, viz., *Nucula* belongs. As mentioned above the 0-group of *Nucula* is difficult to distinguish from the older specimens; but it seems as if the brood appears every year both in Nissum and Thisted Bredning. Thus brood has doubtless been found in Nissum Bredning every year from 1910—1913. In 1914 it cannot be decided if brood has appeared. In 1915 the brood was sparing, but in 1916, on the contrary, there has been plenty of brood. In Thisted Bredning brood seems also to have been found every year from 1911 to 1915. Also in the other Brednings *Nucula* seems to breed rather frequently.

As mentioned above *Nucula* appears in greatest amount in Nissum Bredning. In Lovns Bredning and Skive Fjord it is not found at all, and in the other Brednings it appears rather sparingly. This occurrence can scarcely be caused by want of brood for the reasons mentioned above, but must be due to other causes.

To the second group of animals breeding frequently, but yet not every year, belong *Abra*, *Solen* and *Pectinaria*.

Abra alba breeds rather frequently, in Thisted Bredning no doubt about every other year, in some of the other Brednings perhaps somewhat less frequently. Especially 1915, 1916 and 1917 have been good breeding-years. In 1915 later in the summer very abundant *Abra* brood was found in all Brednings north of Sallingsund. In 1916 rather abundant *Abra* brood was at hand in Lavbjerg and Risgaards Bredning, but not in Thisted and Lovns Brednings. And finally in 1917 there was abundant *Abra* brood in Thisted and Kaas Brednings. How far brood has also been found in the other Brednings cannot be said, as they have not been valued in the autumn of 1917.

Pectinaria perhaps breeds more seldom than *Abra*, but yet rather frequently. It is nearly equally distributed over the whole western part of the Limfjord; it appears both in Nissum and Lovns Bredning, but is perhaps generally at hand in somewhat greater amount in the inmost Brednings. In spite of this wide distribution the occurrence of the brood is often only local. Thus in 1915 a numerous 0-group appears in Livø Bredning, but on the contrary only few in Thisted and Risgaards Brednings, which are in the neighbourhood. As specially good *Pectinaria* years 1913 and perhaps 1917 may be mentioned. In 1913 *Pectinaria* brood appeared in nearly the whole western part of the Limfjord, at any rate in all the Brednings which have been valued. In 1917 abundant brood was found in the 3 examined Brednings, viz. Thisted, Livø and Kaas Brednings. Also 1915 was a comparatively good *Pectinaria* year.

Of *Solen pellucidus*, brood, it is true, appears rather frequently, but the great breeding-years occur only seldom. Moreover this bivalve, when breeding, seems to breed at the same time in great parts of the Limfjord. Thus in 1909 an exceedingly rich breeding-year occurred, which extended over all the median Brednings, from Venø Bugt to Risgaards Bredning and in 1913 a certainly rather slight breeding-year may also be traced, extending from Venø Bugt through Sallingsund and Livø Bredning into Thisted Bredning. In 1911 a good deal of *Solen* brood was found in Thisted Bredning; how far brood has been at hand in the other Brednings during this year, cannot be said for want of investigations. Finally in 1917 very abundant *Solen* brood appeared in Thisted, Livø and Kaas Brednings.

To the third group, seldom breeding, two bivalves belong, viz., *Corbula gibba* and *Mya truncata*.

Corbula gibba breeds rather seldom. In Thisted Bredning, as mentioned above, there has only been one breeding-year of any importance during the period in which the Bredning has been examined, viz., in 1911. The specimens from this year-class may be traced right up to 1916. In a series of median Brednings, from Lavbjerg to Livø Bredning a rather slight breeding-year as far as may be judged has appeared probably in 1909; but specially in the summer of 1913 an exceedingly abundant amount of *Corbula* brood appeared in the greater

part of the Limfjord, especially in all the median Brednings, from Nissum Bredning through Kaas Bredning and Sallingsund to Livø Bredning and thereupon into Risgaards and Lovns Brednings. On the contrary no *Corbula* brood was found this year in Thisted Bredning. The specimens of this year-class are still at hand in 1917 in abundant amount in the Brednings in question. Also in 1914 some *Corbula* brood appeared.

Mya truncata appears only in Thisted, Visby and Lovns Brednings in greater amount as mentioned above. The specimens of this species which appear in Thisted Bredning originate from two different breeding-years. The first of these occurred two or three years before the valuations were commenced, probably in 1907; in the spring of 1910 the average weight of the specimens from this breeding year was ca. 8 g. This year-class can be traced through all the following years, and it can with certainty be shown that during the years 1909 to 1914 new brood has only appeared in minimal amount. Then in 1915 *Mya truncata* brood again appears in Thisted Bredning in rather great amounts, but curiously enough only in the western part of the Bredning. In Lovns Bredning the conditions are about the same; in the spring sample 1910, 23 *Mya truncata* specimens are found per 1 sq. m. having an average weight of ca. 5 g. Although they are somewhat smaller than in Thisted Bredning, yet it is likely that they originate from the same year as the specimens in Thisted Bredning. And also in Lovns Bredning a new 0-group of *Mya truncata* appears in 1915, as is seen from the spring sample 1916.

Of course it would be of great practical and scientific interest to be able to ascertain the conditions, which cause the breeding-years. But our present knowledge of these problems can scarcely solve the question; yet it is of some importance to find out, what may be deduced from the valuation investigations during the past years.

The first question which may be raised is this, where does the new brood come from: it is progeny of the old specimens living in the locality in question, or has it perhaps been brought in a larval stage by the currents in the water? The answer must doubtless be, that even though the amount of different species varies very much, there will, however, always be found enough of old specimens at the bottom to procure new brood. However, it may happen that new brood appears in great amount, though no old specimens of the species concerned are found at the bottom according to the valuation investigations. In Thisted Bredning f. i. no *Corbula* were found in May 1911; in May 1912, on the contrary, 162 specimens per 1 sq. m. were found. It must, however, be remarked, that *Corbula* often occurs very locally, so that it cannot be judged from the May sample 1911 that no *Corbula* at all were living in the Bredning. Most reasonable it is also in this case to suppose that the *Corbula* brood in Thisted Bredning 1911 originates from specimens, which have been living in the mentioned Bredning, and which from accidental causes have not been found in the May sample 1911. In the said year, too, no *Corbula* brood has arisen in the other Brednings of the Limfjord.

The next question then must be: Does the bivalve brood appear every year, and if so, for what reason does the brood then develop in some years and not in others? Or in other words, is the absence of bivalve brood in a certain year caused by the fact that the bivalves do not breed, or that the larvas are killed at a sensitive stage of their development? It is not easy to answer this question because it is not possible yet to determine most of the bivalves in the larval stage. We can only draw on our knowledge of a certain bivalve, whose larva is easily known, viz., the oyster.

The breeding conditions of the oyster have previously been investigated by the Biol. Stat. (see Rep. Biol. Stat. XV, 1907 and XVII, 1908). It will appear from these investigations that in 1895 f. i., when the summer was rather cold and the temperature of the water only for a short time reached over 18°, many oyster larvae were found in the water. Yet the amount was somewhat varying, being comparatively small in cold periods and in warm periods on the contrary large. In 1915, when the summer was also very cold, at the end of July some pelagic brood was found in the water according to the report from the Limfjord oyster company (see Fiskeriberetning for Aaret 1915 pg. 169). This shows us that the oyster no doubt breeds every year, but that the amount of brood in the water increases much with the temperature. Whether the like is the case with the bivalves of the *Abra* community, cannot be said for the present.

With regard to the oyster the same will apply as to the small bivalves, namely, that brood deposition does not take place every year. Thus in 1895 no newly deposited brood was found on the beds, and in 1915, when more than 20.000 half-bushels of shells to catch the oyster broods were thrown out by the oyster company, only very small brood deposition took place. On the other hand there was an exceedingly abundant brood deposition on the ejected shells in 1914. This shows us that the presence of oyster brood in the water is not sufficient to produce brood in the bottom stage. In the development of the oyster there is a sensitive period which justly is supposed to be the moment at which the pelagic oyster larva has to fasten itself.

As seen from the investigations of the Biol. Stat. mentioned above and from the experience gleaned during the oyster cultivation, the oyster larva will generally fasten itself upon objects, stones, wood, shells or the like, which are clean. When such things have been lying in the water during a long time they are covered by a mucilage, probably made by bacteria, diatoms etc. This mucilage seems to prevent the oyster larva from fastening itself, and therefore the brood deposition may be effectively advanced by ejecting or placing cleaned shells, bundles of fagots or the like at the moment when pelagic oyster brood is present in abundant amounts; these things then act as "catchers" of the new oyster brood. This method is used at all places where oysters are cultivated, and is also succesfully used by the Limfjord oyster company.

But besides the oyster larvae having to be present in the water and have fitting objects to fasten upon, there must also be present some external conditions if brood deposition is to take place. The salinity must be up to 3 percent and must at

any rate not be below 2.4 percent. Furthermore the temperature must be rather high. According to the experiences gathered at the places where oysters are cultivated, 18° is the minimum temperature for the deposition of oyster brood. This will also agree with the observations which have been made in the Limfjord. Both in 1914 and 1915 a rather great quantity of clear shells was ejected by the oyster company at certain oyster beds. In 1914 when the temperature during ca. $2^1/_2$ months was above 18° there was a rich brood deposition, in 1915 when the temperature only reached 18° one or two days scarcely any oyster brood was developed.

Thus it is obviously our task to examine, whether the external conditions are also of importance with regard to the appearance of the breeding years of the small bivalves belonging to the *Abra* community. The external conditions particularly to be considered are the salinity and the temperature. Daily measurements of temperature and salinity of the surface water are carried out at Oddesund and Aalborg (see Nautical-Meteorological Yearbook).

Firstly, as to the salinity, this is of great importance to the oyster. But on the other hand it is not likely that the small variations of the salinity appearing in the Limfjord are of any importance to the bivalves of the *Abra* community. The fact is that *Abra* communities are found in water with much less salinity, as for instance in the waters between Nyborg and Svendborg.

To examine the connection between the temperature and the breeding-years I have from the Nautical-Meteorological Yearbook taken the temperature measurements for the years 1908 to 1916; they are put down in table 6. From this table it will appear that the summers 1907, 1909, 1913, 1915 and 1916 must be considered cold summers, as the average temperature for the two stations during the warmest month of the said years respectively was $15,6^0$, $15,8^0$, $16,9^0$, $16,4^0$ and $17,1^0$. In the summers 1908 and 1910 the temperatures in question were 18°; these two years therefore perhaps may be considered as middle years. Finally the temperature during the warmest month of 1911, 1912, 1914 and 1917 respectively was $18,6^0$ $18,5^0$, $19,5^0$ and $18,2^0$. We now shall see, how the matter stands with regard to the amounts of brood during these years. *Nucula* is here left out of account, because it breeds so frequently and we shall only consider *Abra, Solen, Corbula, Mya* and *Pectinaria.*

1909, which was a cold year, was a very rich *Solen* year, especially in all the middle Brednings, further on probably some *Corbula* brood and perhaps some few *Pectinaria* and *Abra* appeared in different places.

In 1910, which was a middling warm year, not very much brood appeared; some *Abra,* however, were found in Thisted and Lovns Bredning. In the latter Bredning also some *Pectinaria* and *Solen* were present.

In 1911, which was a warm year, some brood appeared in Thisted Bredning, especially *Solen,* but also some *Pectinaria* and *Corbula.* In the other Brednings there has probably not been much brood.

In 1912, which was also a warm year, some *Pectinaria* brood arose and in

Thisted and Nissum Brednings some few *Abra*; otherwise only a slight amount of brood seems to have been present.

In 1913, which was a cold year, a very numerous *Corbula* brood arose in the median Brednings. Besides there was very much *Pectinaria* brood and in somewhat smaller amount brood of *Solen* and *Abra*.

In 1914, which was a very warm year, a very great deposition of oyster brood took place, as mentioned above. Unfortunately there are only very few valuations at hand for this year. Yet it seems, as will also be seen from the June valuations of 1915, that very little brood appeared in 1914. There has been no *Mya* brood, hardly either any of *Pectinaria* and *Solen*, but on the other hand a little of *Abra* and *Corbula*.

In 1915, which was a cold year, a lot of *Abra* brood was found over great parts of the Limfjord. Besides *Mya* brood appeared in Thisted and Lovns Brednings and locally some *Pectinaria* and in Livø Bredning some *Solen*.

In 1916, which was also a cold year, there was rather much of *Abra* brood; otherwise scarcely any brood was developed.

In 1917 which was a warm year, *Abra*, *Solen* and *Pectinaria* brood were very rich in Thisted, Livø and Kaas Brednings.

From this it seems to appear, that it is not even in the warmest summers that the greatest brood development takes place. The small bivalves therefore seem to be dependent on the temperature in another way than the oyster. This is in itself not so curious. The oyster, with us, lives in the neighbourhood of the limit of its northern distribution, so that it is easily understood that it only breeds in the warm summers. Of the small bivalves *Mya truncata*, on the other hand, is more particularly an arctic bivalve (according to C. G. Joh. Petersen, Om de skalbærende Molluskers Udbredningsforhold). *Nucula* has rather a wide distribution. *Corbula*, besides in the Mediterranean, is also found at the north coast of Finland, but *Abra* and *Solen* are of more particularly southern occurences. For these reasons there is nothing to prevent them from breeding with us in cold summers. Any clear connection between the temperature of the sea-water and the breeding-years cannot, however, be deduced from these investigations.

The possibility should also be taken into consideration that it may not be the variations in the external factors such as temperature and salinity which condition the breeding-years, but on the contrary variations in the amount of predatory forms. It is an obvious conclusion that a great deal of the tender bivalve brood is eaten up shortly after it has sunk to the bottom, f. i. by *Ophioglypha*, and then it might be supposed that variations in the amount of *Ophioglypha* might act upon the amount of the bivalve brood which is going to be developed. As far as may be seen from the valuation investigations the amount of *Ophioglypha* yet seems to vary only a little year by year.

The oyster fishery has taught us how injurious storms may be to the oyster brood, because it is covered with a layer of dead sea-weed and detritus which

smother the new brood. It is possible that this fact is also of some importance for the bottom animals mentioned here. Then the often rather local appearance or non-appearance would be explained.

Summary.

The aim of these investigations has been on the basis of the valuations made in the Limfjord by the Biol. Stat. to study the animals which serve as food for plaices and eels with regard to 1. the variation year by year, 2. breeding-years, 3. annual production, 4. rate of growth and also 5. to throw light upon the connection between the amount of food and the plaice fishery.

1. The variation of the amount of food. It has proved that the stock of bottom animals, serving as food for plaices and eels, varies very much year by year in a double sense, partly quantitatively, as the whole amount of fish food is rather different in the different years, partly qualitatively, as it is different species which dominate among the bottom fauna during the different years. These variations are seen rather plainly in the plate, where 1911 must be characterised as a year with only a slight food amount, and *Abra* dominating, while 1912 has been a rich year with Solen as domininating bottom animal. The amount of food in the spring samples of Thisted Bredning varied during the years 1910—1917 between 22,8 and 60,8 g. rough weight per 1 sq. m.

These variations are caused by the fact, 1. that of most of the animals, serving as fish food, the brood is not developed each year in greater amount, 2. that they are quickly eaten up, so that they as a rule do not grow older than one year and 3. that the different species of bottom animals breed in different years.

2. Breeding-years. The frequency of the breeding-years varies much for the different species. *Abra* breeds about every other year, *Solen* somewhat less frequently, *Mya truncata* seems only to breed with an interval of many years. It has not been possible to show any connection between the appearance of the breeding-years and the external factors, as for instance the temperature. As mentioned above the breeding-years of the different bottom animals are not coincident, and the appearance of the brood often seems to be quite local.

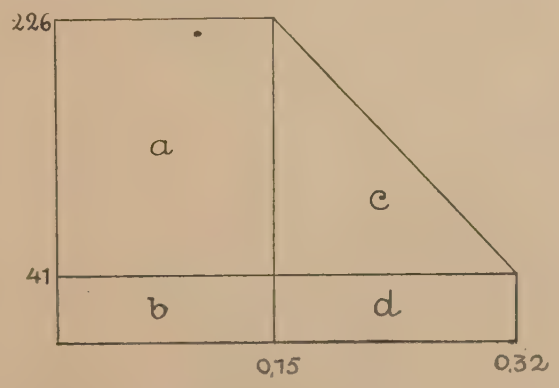
3. The annual production. With regard to Thisted Bredning it has been possible with a certain approximation to determine as well the quantity of the annual consumption as the annual production. The magnitude of the annual consumption by which is understood the amount eaten during a year, varies in about the same way as the spring stock, because it is especially the spring stock which is eaten up during the next year. The annual production is the sum of the growth increment for the animals which form the spring stock and the amount of brood which is added during the year. The magnitude of the annual consumption in Thisted Bredning has varied between 31.8 and 84.3 g. rough weight per 1 sq. m. The

magnitude of the annual production during the years 1910—1915 has varied between 42.1 and 77.1 g. rough weight per 1 sq. m.

4. The rate of growth. It seems as if the bottom animals which have been examined continue their growth during their whole life. At any rate this will apply to *Corbula* and *Mya truncata*, where a certain year-class can be traced through many years. Curves, indicating the rate of growth in some of the bottom animals are found pg. 17, 18 and 28. Besides there is no doubt that the rate of growth varies very much year by year and from place to place.

5. The connection between food amount and plaice fishery in Thisted Bredning. For several reasons complete agreement cannot be expected between the amount of food and the plaice fishery. Briefly it may be said, that the plaice fishery was especially good in 1909 and 1910; during the later years it has decreased very much and it was specially bad in 1916. The great fishery in 1909 is coincident with a great stock of young *Mya;* during the years 1910 to 1915 the amount of food has been varying, but every year, however, brood of one or another species has appeared; in 1916, on the other hand, the amount of food was very small, and we may no doubt take it for granted that the great reduction of the food amount in 1916 is the cause of the great decrease in the plaice fishery at the same time. In 1917 no plaices were transplanted, and for this reason this year cannot be sided with the other. At any rate it must be said, that an unlimited amount of fish food is not at hand, and therefore transplantation can only be made with profit within certain limits. It seems as if the limit already in certain years has been surpassed, and this must be regarded as one of the main results of the valuation investigations.

Note. According to a method found by cand. mag. H. Blegvad the quantities mentioned pg. 12, entering into the calculation of the annual production and consumption, may be represented in the following way.

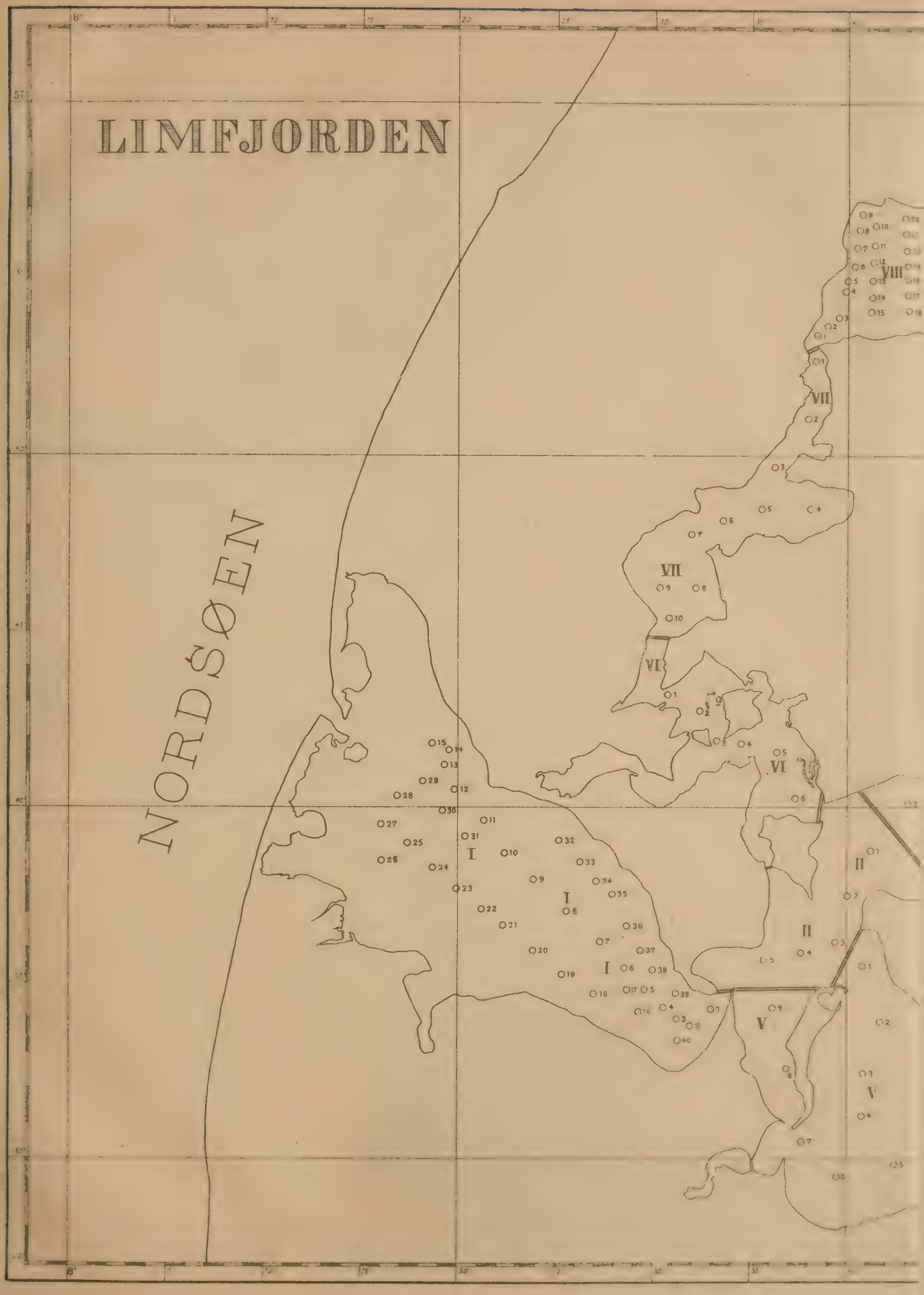


In the curve system here presented the ordinate indicates the number of animals and the abscissae their average weight. In the calculation of consumption and annual production of *Solen* in 1912 (see the figures uppermost pg. 10) it will f. i. be found as follows: The stock of 1912 is indicated by the area a+b (number, 226 × average weight 0.15). The stock of 1913 in the same manner by the area b+d. The growth increment in the old bivalves is indicated by c+d. d is the growth increment in the bivalves yet living in 1913, c is the growth increment of the bivalves which have died in the course of the year. These are supposed at the moment of death to have a weight being the mean between the average weights in 1912 and 1913. Consumption = stock 1912 + growth increment ÷ stock 1913 = a + b + c + d ÷ b ÷ d = a + c.

Explanation of the Plate.

The amount of the plaice food per $^1/_5$ sq. m. in Thisted Bredning in the samples of 1911—1914. Of the polychætes only *Pectinaria* has been taken; besides, *Philine* and *Acera* are wanting. All *Abra* specimens belong to the 0-group. Of *Solen* there were old specimens in 1911 (1 sp.), 1913 (8 sps.), and 1914 (1 sp.), the rest is 0-group. Of *Nucula* there were in 1911 3 old specimens, in 1912 11 old and 6 of the 0-group, 1913 7 old and 4 of the 0-group and in 1914 7 old and 2 of the 0-group. Of *Corbula* there were no specimens in 1911; in 1912 there were 1 old specimen and 31 sps. of the 0-group. In 1913 and 1914 there were only old specimens. Of *Pectinaria* there is only one old specimen in 1912, the rest is 0-group. In *Corbula* the growth of the 0-group 1911 may be traced through 3 years; in some specimens the annual rings are distinctly seen. It will be observed, that in 1911 there has been very little plaice food, while the 3 other years, especially 1912, must be designated as rather good years.

1911
1912
1913
1914
Abra
Solen
Nucula
Corbula
Pecti-
naria


LIMFJORDEN
NORDSØEN

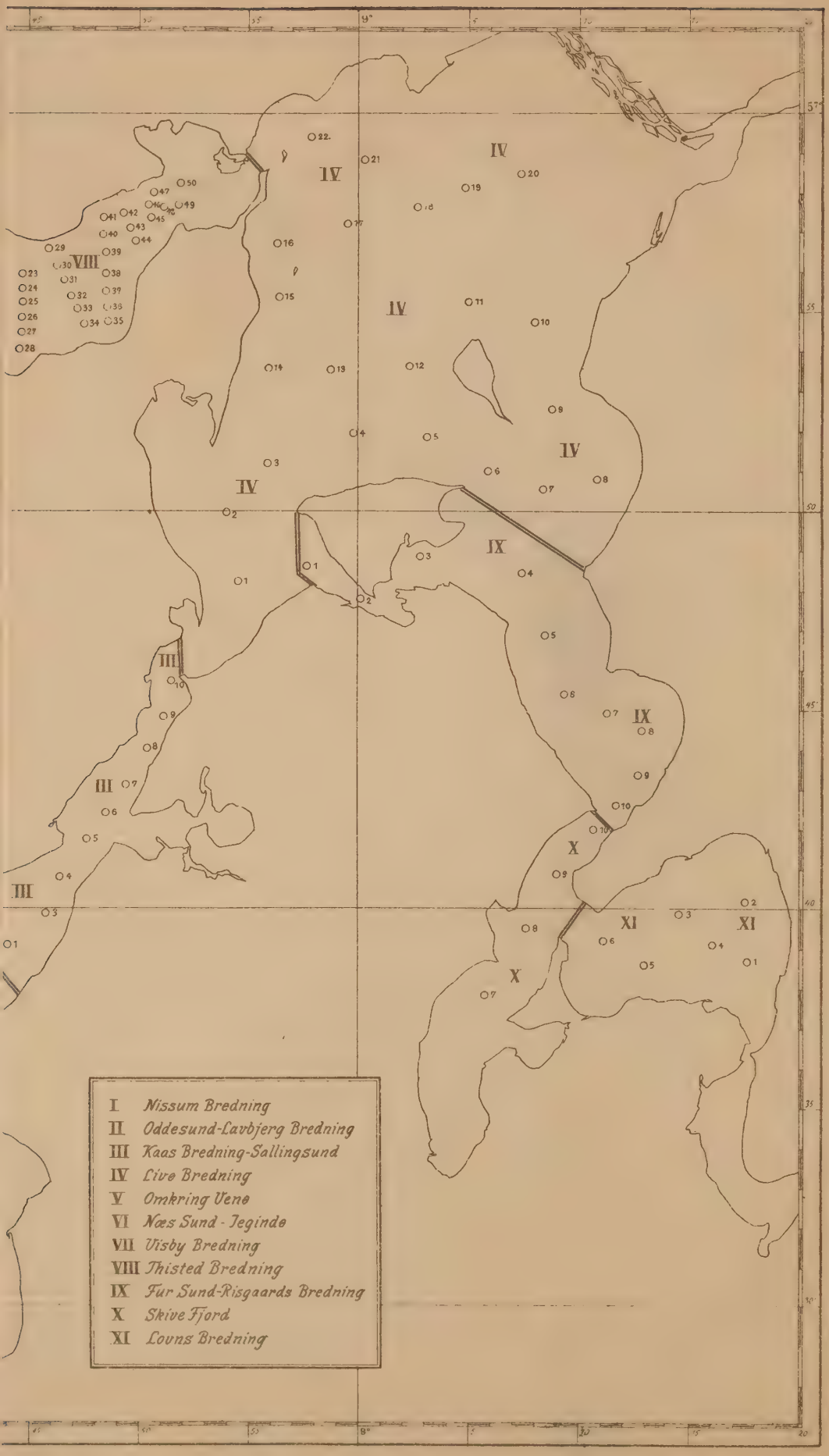

I Nissum Bredning
II Oddesund-Lavbjerg Bredning
III Kaas Bredning-Sallingsund
IV Live Bredning
V Omkring Vene
VI Næs Sund - Jeginde
VII Visby Bredning
VIII Thisted Bredning
IX Fur Sund-Risgaards Bredning
X Skive Fjord
XI Louns Bredning

Table I.

Number and rough weight in gr. per sq. m. of the common bottom animals in Thisted Bredni

A. = Number. V. = Rough weight in gr. per sq. m.		1909.	1910.		1911.		1912.		1913.		1914.		1915.		
		Oct.	April.	Oct.	May.	Oct.	May.	Oct.	April.	Sept.	April.	Sept.	June.	Aug.	May.
1. Ostrea edulis	A.	0,1	0,2		0,1	0,1		0,4	0,2	0,2					
	V.	?	?		2,3	13,5		16,3	2,2	2,7					
2. Mytilus edulis	A.	0,5	0,8	0,8	1,2	?	0,1	5,2	0,4	0,2	3,4	1,6	1,9		42,2
	V.	?	?	4,0	8,7	45,6	0,8	74,0	16,2	9,4	80,0	49,4	115,9		20,1
3. Mya truncata	A.	13,9	24,3	24,4	17,8	21,9	20,2	21,4	16,6	11,2	16,0	6,8	7,8	14,0	6,4
	V.	66,0?	199,6	250,0	225,0	294,0	304,0	306,0	270,0	190,0	312,0	93,9	192,8	268,0	140,0
4. „ „ juv.....	A.	4,8	0,2	1,6	0,8	1,3	2,2	1,6	3,6	1,4	1,2	2,6	5,8	4,0	67,4
	V.	18,8	?	?	1,5	1,0	1,2	1,1	0,7	0,9	0,9	0,5	0,9	2,6	20,1
5. Abra alba	A.	6,4		83,8	50,1	7,9	2,0	70,8	60,4	4,0	11,0	164,0	486,8	105,0	9,2
	V.			11,2	9,3	0,8	×	6,3	6,0	0,9	2,0	10,3	44,2	27,8	1,2
6. Solen pellucidus	A.	29,2	38,1	9,8	15,6	226,1	226,0	79,2	103,0	62,0	52,8	61,2	15,6	14,0	12,4
	V.		4,6	1,7	4,0	19,4	32,8	14,6	20,0	3,6	11,6	5,0	3,9	3,4	2,1
7. Nucula nitida.....	A.	39,5	43,9	45,3	16,4	57,3	83,2	45,4	54,6	38,2	46,4	21,2	61,6	63,0	35.
	V.		3,6	4,7	1,6	5,9	7,1	5,2	5,3	4,2	4,8	2,1	4,7	5,0	3,
8. Corbula gibba	A.	0,3	0,6	0,2		50,4	161,8	11,2	90,4	22,6	57,2	10,8	43,0	15,0	21 .
	V.		?	0,1		1,7	3,9	0,5	3,4	1,1	3,4	0,8	3,2	0,5	1,6
9. Cardium fasciatum ...	A.	2,6	7,1	2,5	0,9	4,8	7,2	1,8	1,8	1,2	9,4	5,6	2,8		4,6
	V.		1,2	0,2	0,3	0,2	0,6	0,1	0,3	0,1	1,2	0,2	0,4		0,2
10. Pectinaria koreni	A.	92,4	66,0	10,5	11,7	97,3	58,0	28,4	44,6	215,2	118,4	24,2	3,4	61,0	99,4
	V.		7,0	2,2	3,2	14,3	12,2	6,2	7,0	13,3	15,5	3,9	0,4	5,4	5,0
11. Terebellidæ	A.		4,1			1,1	1,8	3,8	4,8	1,8	2,2	0,8	1,0		
	V.		0,7			0,2	0,9	0,7	2,4	0,5	1,0	0,1	×		
12. Aphrodite aculeata ...	A.	0,8	1,1	0,8	0,7			0,4	0,4		0,2			1,0	
	V.		1,8	?	1,4			0,3	0,6		1,0			3,3	
13. Vermes var.	A.	34,7	40,3	30,1	20,0	56,7	49,2	48,2	c. 34,0	41,2	43,8	27,4	41,8	21,0	30,4
	V.		3,3	2,9	2,1	3,8	4,6	3,1	3,4	2,9	5,4	1,8	2,9	2,5	4,5
14. Philine aperta	A.	11,3	16,0	6,3	0,9	17,8	15,8	12,6	4,0	54,6	66,0	5,0			14,4
	V.		0,4	0,2	0,1	0,7	0,8	0,6	×	2,6	3,1	0,2			0,5
15. Acera bullata	A.		3,2	2,3	1,6	3,5	1,6	0,8	1,8	2,6	1,2	0,4			
	V.		0,4	0,3	0,3	0,3	0,6	0,1	0,4	0,3	0,3	×			
16. Buccinum undatum...	A.	1,3	0,5	0,8	0,7	0,5	0,4	1,0	0,2	0,6	0,6	0,4	0,4	1,0	0,2
	V.	c. 4,1	2,7	3,3	4,7	2,8	1,0	13,0	1,4	6,2	12,0	5,0	0,2	0,4	1,0
17. Nassa reticulata	A.	4,5	5,3	3,0	2,2	2,9	2,4	1,4	2,6	1,6	1,0	2,2	1,0	1,0	1,0
	V.		4,9	2,5	3,4	3,2	2,4	2,0	1,7	2,4	1,2	2,6	0,7	1,5	1,2
18. Nassa pygmæa.....	A.	?				0,2				1,8	0,2	9,8	1,8	3,0	0,2
	V.					×				0,1	×	0,5	0,1	0,2	×
19. Ophioglypha texturata	A.	102,6	86,0	45,7	53,5	155,2	101,4	211,2	145,6	140,8	157,2	121,0	86,6	78,0	52,6
	V.		10,2	7,2	9,5	16,4	9,8	20,4	13,8	13,5	17,0	11,1	8,4	7,9	5,1
20. Asterias rubens	A.	0,9	1,1	0,6	0,8	2,3	3,6	1,0	1,6	0,8	2,2	0,4	0,4		0,2
	V.		4,1	0,5	2,5	0,4	2,2	3,6	0,5	30,5	2,3	1,1	1,7		2,7
21. Echinus miliaris.....	A.	1,1	1,8	1,2	1,8	1,7	1,6	1,6	0,2	1,8	2,0	0,8	4,4	1,0	1,2
	V.		4,0	1,6	2,0	4,1	1,3	0,9	0,3	1,2	1,2	0,8	1,3	0,3	0,9

I 1919, 1910 and 1911 100 samples of 0,1 sq. m. were taken, later only 50; and in August 1915 only 10 samples, distributed throughout the whole of the Bredning.

We have omitted from these lists some animals of the epifauna from the Zostera and from a few stones in the *Abra* community; they represent only a small quantity. – *Modiola* and *Cyprina* are also not included here.

ng.

1916.		1917.	
July.	Sept.	May.	Oct.
0,2		0,4	
8,0		20,0	
9,4	0,8	27,8	1,4
84,3	0,1	120,0	0,9
11,4	10,2	8,2	7,6
246,0	165,1	204,0	114,0
83,6	48,8	19,6	32,2
42,0	42,0	36,0	80,0
9,8	19,2		264,6
0,4	1,0		39,7
4,2	5,0	4,8	242,0
0,9	0,3	0,4	26,7
32,4	31,6	23,6	22,4
3,0	3,2	1,9	2,2
26,0	19,4	1,2	6,0
2,0	1,3	0,1	0,2
1,2	21,2	12,2	4,6
×	0,3	1,3	0,6
5,0	4,0	8,6	170,8
0,9	0,5	0,8	13,2
0,4	1,2	1,2	0,4
×	×	0,2	×
	0,2		
	1,0		
37,2	39,8	39,4	45,4
2,9	2,3	2,2	3,6
7,0	3,4	2,6	8,2
0,1	0,1	0,1	0,3
	1,4		0,4
	×		×
0,4		0,2	0,2
3,7		1,0	1,5
1,6	0,6	0,2	
2,2	0,6	0,1	
0,4	0,4		
×	×		
71,8	88,8	74,0	65,2
8,0	10,4	7,3	8,0
0,6	1,0	0,8	2,0
10,0	3,0	3,0	3,8
0,4	1,2	0,4	1,2
0,3	0,8	0,5	1,3

Table II.

Calculation of consumption and annual production in Thisted Bredning (the

	1910			1911			1912			1913		
	old spec. numb.weight / 0-group numb.weight	consumption	growth increment / up growth	old spec. numb.weight / 0-group numb.weight	consumption	growth increment / up growth	old spec. numb.weight / 0-group numb.weight	consumption	growth increment / up growth	old spec. numb.weight / 0-group numb weight	consumption	growth increment / up growth
Mya truncata juv.												
Abra alba	0	5,3	0 0,3 5,3	0 50 9,3 5,0	ca.10,5	1,2	0 2	1,0	0 6,0 1,0	0 60 6,0 41,0	10,2	4,2 2,0
Solen pellucidus	38 4,6	8,6	6,0 2,0	2,0 10,6 2,0 16,1	5,1	1,1 32,5	0 226,0 32,5 54	42,5	22,9 6,8 1,8	13,2 62 6,8 34,6	29,7	10,9 10,1 1,2
Nucula nitida	43,9 3,6	3,0	1,2	1,6	?	? 1,5 0	5,6 29 1,5	4,9	1,3 1,7	4,0 20,0 1,3 90,1 3,1	2,3 1,6	0,6 1,6
Corbula gibba	0	0	0	0	0	3,9	161,8 3,9	2,2	0			0
Cardium	7,1 1,2		0	0,9 0,3	0,3	? 0,6	7,2 0,6	0,6	? 0,3	1,8 0,3	0,3	? 1,2
Pectunaria	66 7,0	16	9,8 2,1	1,3 0,8 10,4 2,4	2,6 4,4	2,1 9,5 4,4	5 2,7 53 9,5	19,8	0,9 5,6	2 1,4 42,6 5,6	15,6 9,2	8,6 15,5 9,2
Vermes var. (excl. Pectinaria)	45,5 5,8	5,8	? 3,5	20,7 3,5	3,5	? 5,5	51,0 5,5	5,5	? 4,0	39,2 6,4	6,4	? 7,4
Philine			?			?			?			?
Acera	19,2 0,8	0,8	0,1	2,5 0,1	0,1	1,1	17,1 1,1	1,1	0,1	5,8 0,1	0,1	3,1
Sum of rough weight	23,0	39,5	19,2 22,9	22,3	31,8	6,1 65,6	60,8	77,9	35,1 25,4	48,8	75,7	26,1 49,7
Annual production			42,1			72,0			60,8			76,2
Organic dry matter		4,29			3,45			8,50			8,47	

gures indicate number and rough weight in g. pr. sq. m)

1914			1915			1916			1917		
old spec. numb.weight / 0-group numb.weight	consumption	growth increment up growth	old spec numb.weight / 0-group numb.weight	consumption	growth increment up growth	old spec. numb weight / 0-group numb.weight	consumption	growth increment up growth	old spec. numb.weight / 0-group numb.weight	consumption	growth increment up growth
								67,1	19,6		
			April			67,1	51,2 ?		36,0		
					20,1	20,1		0			
0		0,8	0		ca. 16,5	1,0					
11	2,8			ca. 40		0,5	1,9	0,7			
2,0		ca. 24,0	ca. 160	+		8,2	2,0	0	0		
			ca. 24,0	ca. 18	ca. 18	0,7		2,0	0		>39,8
3,0		4,2	0		ca. 6,0	0		0,4	1		
1,2	15,8			ca. 15,0			2,3		0,2		
49,8		9,0	ca. 60		2,1	12,4		0,2	3,8		>26,7
10,4			ca. 9,0			2,1			0,2		
34,0		1,2	17,8		2,3	11,3		0,2	15,8		
4,2	3,5		2,5	5,5		1,5	1,8		1,5		
12,4		2,2	43,8		1,6	24,3		0,4	7,8		
0,6			2,2			1,6			0,4		
57,2		0,7	43,0		0,1	21,0		0,1	1,2		
3,4	0,9		3,2	1,7		1,6	1,6		0,1		
		0			0			0			
		?			?			?			
9,4	1,2	0,4	2,8	0,4	0,2	4,6	0,2	1,3	12,2		
1,2			0,4			0,2			1,3		
		14			0,4			11,3			
118,4	29,5	0,4	3,4	0,8	5,6	99,4	16,9	0,8	8,6		
15,5			0,4			5,6			0,8		>13,2
		?			?			?			
46,2	7,4	2,9	42,8	2,9	4,5	30,4	4,5	2,2	39,4		
7,4			2,9			4,5			2,2		
		?			0						
67,2	3,4	0	0	0	0,5	14,4	0,5	?	2,6		
3,4						0,5		0,1	0,1		
		20,9			(29,2)						
49,3	64,5	38,9	(44,6)	(84,3)	(47,9)	34,2	?	7,0	42,8		
		59,8			77,1						
	8,43			(7,16)							

Table III.

Number and rough weight in gr. per sq. m. of the common bottom animals in Nissum Bredning.

		1910.		1911.		1912.		1913.		1914.		1915.		1916.		1917.
A. Number. V. Rough weight in g per sq. m.		April.	Oct.	May.	Oct.	May.	Sept.	April.	Sept.	April.	Sept.	June.	Aug.	May.	Sept.	May
	A.	30,3	1,0		27,8	4,5	112,0	73,0	112,8	62,5	4,5	11,0		1,5	17,3	10,8
1 Abra alba	V.	3,0	0,2		3,4	0,3	17,6	7,3	6,1	2,9	0,3	0,4		0,5	2,7	0,9
	A.	6,8	16,5	11,3	69,5	21,3	69,5	36,0	10,8	8,8	31,5	31,3	11,0		46,5	8,8
2. Abra nitida	V.	?	0,9	0,8	3,9	1,2	3,3	3,6	0,5	0,3	0,8	0,9	0,5		2,6	0,5
	A.	8,8	16,5	3,0	20,0	2,8	10,8	4,5	18,5	23,5	3,5	1,0		2,5	7,8	1,5
3. Solen pellucidus	V.	1,2	1,4	0,4	1,7	0,6	0,6	0,5	0,8	1,0	0,2	0,1		0,1	0,8	0,1
	A.	266,0	456,8	499,3	607,3	591,0	457,8	536,0	455,0	396,0	290,3	190,5	31,0	117,3	150,8	235,0
4. Nucula nitida	V.	14,1	26,4	28,8	48,9	48,3	46,4	44,7	41,8	34,3	17,8	16,9	2,2	9,0	8,7	10,5
	A.	14,3	32,3	18,5	66,8	135,3	54,3	73,5	164,8	231,3	1067,0	1520,8	2365,0	898,8	984,0	594,3
5. Corbula gibba	V.	1,6	2,8	1,8	4,9	10,5	3,9	3,0	9,7	8,3	57,0	83,9	191,0	67,5	108,9	56,3
	A.	5,8	3,8	7,0	6,8	7,3	13,5	8,5	34,5	46,3	6,0	3,5		4,5	6,3	15,0
6. Macoma baltica	V.	2,8	1,5	5,6	2,1	3,9	5,4	2,5	1,9	2,5	0,8	1,2		1,6	0,5	2,7
	A.	10,3	0,5	1,3	0,5	0,8	2,5	1,5	7,0	6,5	1,3	0,8		1,0	1,0	0,3
7. Tellina fabula	V.	0,2	0,1	0,1	×	0,1	0,2	0,1	0,4	0,3	0,1	0,1		0,5	0,1	×
	A.	21,5	39,3	5,5	53,3	2,8	105,3	19,5	28,8	12,5	5,3		19,0	2,8	24,8	1,8
8. Pectinaria koreni	V.	4,8	8,6	1,7	12,1	0,9	19,7	5,1	4,6	2,4	0,4		1,4	0,4	2,3	0,4
	A.	5,0	1,3		26,0	1,0						0,3				0,8
9. Terebellidæ	V.	1,2	0,3		5,0	0,3						?				×
	A.	0,3	1,3	0,5	0,3					0,5						
10. Aphrodite aculeata	V.	0,2	5,0	0,6	3,4					6,1						
	A.	60,8	36,3	41,0	53,3	57,8	c. 58,0	57,0	66,8	72,0	26,5	39,5	30,0	37,3	57,3	69,0
11 Vermes var.	V.	3,8	3,1	2,9	4,0	c. 3,9	4,8	3,5	3,5	5,0	1,6	2,0	1,7	1,8	2,3	4,6
	A.	10,0	11,8	3,3	73,5	10,8	21,8	18,0	71,0	13,5	17,8	0,8	6,0	4,5	61,8	14,0
12 Philine aperta	V.	0,6	0,5	0,1	2,1	0,5	1,0	0,1	2,9	0,6	0,1	0,1	0,2	0,2	1,7	0,1
	A.		0,3			0,5	0,8	2,0		0,3	0,5			0,3	0,5	0,3
13. Buccinum undatum	V.		0,8			?	8,3	27,4		3,9	7,6			1,0	3,9	3,1
	A.	2,8	0,5	0,8	0,3	0,8	1,3	1,5	1,5	1,3	0,8	0,3	1,0			
14. Nassa reticulata	V.	?	1,0	1,4	0,2	1,1	2,3	4,6	2,1	1,8	1,1	0,9	1,2			
	A.	2,5	8,0	5,8	21,5	7,3	15,8	18,5	40,5	23,0	41,3	14,0	36,0	19,5	30,8	15,5
15. Nassa pygmæa	V.	?	0,6	0,4	1,5	0,6	1,0	1,4	2,1	1,2	2,6	0,7	1,5	0,9	2,4	0,9
	A.					2,5	1,3	2,0	4,0	4,3	1,5	1,5	1,0	0,3	1,0	3,8
16. Ophioglypha albida	V.	?	?	?	?	0,6	0,3	0,7	1,0	0,7	0,2	0,5	0,2	×	0,3	0,4
	A.	36,0	40,8	34,0	61,0	37,8	60,3	78,5	55,3	36,3	23,8	13,3	18,0	9,5	5,8	7,5
17. Ophioglypha texturata	V.	12,6	12,9	9,1	16,3	10,5	19,8	21,5	19,7	11,1	8,6	6,0	5,5	3,3	2,9	3,4
	A.	0,5	0,5	0,8	0,8	0,3	1,3	1,5		0,5		0,3		0,5		0,3
18. Asterias rubens	V.	1,9	1,3	11,1	8,2	6,4	11,9	18,0		4,0		2,4		6,1		1,4
	A.	3,5	5,5	5,3	5,5	2,0	1,8	1,5	2,5	2,0	19,8	13,7	7,0	15,8	13,3	3,0
19. Echinocardium cordatum	V.	50,8	82,8	87,8	107,5	33,0	40,6	37,5	c. 50,0	39,2	142,3	145,6	88,0	165,0	172,5	28,8
	A.						41,5	60,0	30,3	41,3	0,8				2,5	
20. Echinocardium cordatum juv.	V.	?	?	a few	?	?	29,9	100,0	c. 190,0	282,5	0,5				0,8	
	A.	0,8	1,0		2,3	2,0	7,8		0,5		1,0	2,0			2,0	
21. Echinus miliaris	V.	1,0	1,5		2,1	2,8	8,2		1,3		1,2	2,6			5,4	
	A.	0,5	5,8	1,8	5,3	0,3	c. 105,0		7,0		7,3				2,8	
22. Ascidiella	V.	2,6	32,5	18,9	19,1	1,4	273,2		36,3		6,9				6,1	

40 samples of 0,1 sq. m. were taken each time, only in April 1913 20 and in August 1915 10.
Some epifauna, especially *Pomatoceros* and *Balanus*, on some stones, are omitted, as also a few larger animal forms.

Tab. IV. Number and rough weight in gr. per sq. m. of the common bottom animals in the other Bredningers of the Limfjord.

Locality.		Oddesund-Lavbjerg Bredning.							Northern Kaas Bredning-Sallingsund.									Livø Bredning.								Round Venø.				Næs Sund-Jegindø.					Visby Bredning.			Fur Sund-Risgaards Bredning.						Skive Fjord.				Lovns Bredning.					
Year.		1910.	1912.	1915.	1916.			1917.	1910.	1912.	1913.	1915.	1916.			1917.		1910.	1913.	1915.	1916.			1917.		1910.	1913.	1915.	1916.		1915.	1916.		1917.		1915.	1916.	1917.	1910.	1913.	1915.	1916.			1917.		1910.		1915.	1916.		1917.
Month.		May	Oct	Aug.	May.	July	Sept	May	April	June.	Oct.	Sept	Aug.	May	July.	Sept.	May.	Oct.	June.	Sept.	Aug	May	July.	Sept.	May.	Oct.	May.	Sept.	Aug.	May.	Sept.	Aug.	May.	July.	Sept	May.	Aug.	Sept.	May.	June.	Sept.	Aug.	May	July	Sept	May.	June.	Aug.	May.	Sept	May.	May.	Oct.	Aug.	May.	Sept	May.
Ostrea edulis	A.																				1,0			0,9																													
	V.																				19,3			37,1																													
Mytilus edulis	A.																				1,0	1,0		1,8		8,0					2,2					1,0	70,0	1,0				15,0	33,0	2,0	45,0		77,5		55,0			26,0		30,7	1,7	75,0
	V.																				31,3	29,1		118,2		32,0					0,1					34,5	4,7	60,8				24,3	45,9	4,2	160,0		447,3		37,0		?	173,8		300,0	3,7	1333,3
Mya arenaria	A.									1,0																																										
	V.									2,5																																								77,0	8,0		12 juv.	3,3	
Mya truncata	A.									13,0						3,0		1,0	5,4			0,5	0,9		1,0		3,8					1,7			12,0	2,0	1,0	13,9	38,0	10,0	5,0	0,0	5,0	7,0	30,0		5,0	5,0	5,0	23,0	8,0		1,7	
	V.									3,5						120,0		22,4	54,0			8,7	16,1		14,3		69,3					50,0			334,0	63,5	28,5	80,9	370,0	114,5	76,0	122,0	60,0	100,0	257,0		127,5	70,5	178,0	119,5	21,4		5,8	
	A.	2,2							1,8		9,0					2,0		3,0	24,9	1,3	13,8	1,4	0,4	4,1	4,0	5,0	1,7		1,1							35,0			30,4	46,0	6,0	3,0	4,0	6,0	19,0		10,0	* 2,5	*) 2,5	2,5		5,0	28,0	*) 10,0	11,7
Mya truncata juv.	V.	0,6							0,6		1,4					0,2		0,3	9,8	4,6	0,9	0,1	1,0	0,5	1,7	1,5	><		0,2				1,7			1,0			12,0	150,0	7,8	4,5	3,8	5,2	10,5		1,1	3,0	0,3	0,2		0,8	17,1	14,5	15,0
	A.	6,7	30,0	34,0		146,0	18,0				79,0	92,0	12,0		195,0	92,0	10,0	144,0	22,8	28,8	387,1	36,4	151,4	40,9		50,0	266,7	565,5	8,9	12,2	122,2	48,3		15,0	3,8																				
Abra alba & nitida	V.	0,6	2,8	1,8		18,6	2,8				9,1	6,9	1,2		14,6	5,0	0,5	17,2	0,8	4,8	11,3	1,6	11,3	3,7		6,9	42,8	42,8	1,7	0,2	13,8	7,8		3,3	1,2																				
Solen pellucidus	A.	55,6	10,0	6,0		8,0	16,0	2,0	723,5	1153,0	128,0	87,0		2,0	5,6	23,0	13,0	1148,0	71,8	60,0	99,0	180,4	34,1	68,6	23,0	668,0	1716,7	331,8	3,8	4,4	12,2	1,7			5,0	1,7	10,4																				
	V.	8,4	0,3	0,4		0,8	0,8	0,4	123,5	158,5	26,1	5,0		0,2	0,8	2,1	3,1	172,4	14,3	6,6	5,2	19,8	7,0	5,1	1,9	76,6	189,8	19,1	0,6	0,3	0,1	0,2			0,5	0,2	6,0	3,0	1,0	31,4	13,1	12,2	3,8	2,1	1,7	2,7	2,0	1,0	1,8	0,8		4,6	20,4	0,2	0,2		
Nucula nitida	A.	15,6	89,0	110,0	40,0	40,0	30,0	44,0	52,9	63,0	117,0	83,0	78,0	90,0	64,0	76,0	98,0	89,0	70,3	41,8	81,9	74,1	69,5	64,1	62,0	65,0	31,7	118,2	23,3	47,5	0,7				3,3			53,5	108,0	22,0	49,0	41,0	46,0	14,0	2,0				2,5		1,0				
	V.	2,0	13,1	16,6	4,0	5,6	4,1	6,1	8,0	0,0	16,7	8,2	14,2	14,1	11,0	12,0	10,3	10,0	6,7	5,5	8,0	7,6	9,0	5,1	3,5	5,0	5,1	9,8	1,3	4,7	0,3				0,3			7,2	11,5	3,2	4,3	3,2	3,5	1,3	><				0,3		0,1				
Corbula gibba	A.	47,8	553,0	2340,0	764,0	530,0	370,0	490,0	88,2	466,0	1414,0	832,0	2087,0	2295,0	2375,0	2659,0	961,0	244,0	31,3	476,3	266,7	233,6	323,2	288,2	122,0	53,0		107,3	460,0	318,9	312,2				2,1	1,0																				
	V.	8,1	119,8	263,8	98,0	105,2	69,6	78,6	15,0	78,5	163,1	103,5	290,6	250,0	330,0	375,0	105,6	35,6	4,0	78,8	24,1	15,1	23,3	19,0	10,4	4,9		4,8	27,1	23,2	24,7				0,2	0,2																				
Macoma baltica	A.																					0,8																															
	V.																					0,1																															
Cardium fasciatum	A.		1,0						0,6	4,0				1,0		4,0	3,0	6,9			4,8	10,8	3,2	45,9	21,0	8,0		2,7				1,7	1,0	1,0	2,0	22,6		*) 7,0	* 5,0	*) 0,0	47,0	125,0	**) 2,0	** 5,0	** 2,5	2,5	9,6	2,0	**) 5,0	** 25,0							
	V.		0,1						><	1,0				0,1		0,3	0,2	1,2			0,4	0,5	0,2	0,8	2,5	0,5		0,1				0,2	0,2	0,1	0,1	3,0				0,5	0,2	0,5	1,7	10,1		0,1	0,2	0,2	0,5	1,5	0,1	0,1	1,3				
Pectinaria koreni	A.	57,8	107,0	174,0		52,0	98,0		23,5	23,0	126,0	200,0	29,0	2,0	12,0	133,0	8,0	366,0	38,2	77,8	563,8	270,8	36,4	25,9	4,0	367,0	103,8	126,4	15,6	1,1	12,2	3,3	1,7		1,7		238,0	3,0	8,0	25,7	278,0	30,0	15,0	2,0	9,0	4,0		7,8	7,3	2,5		39,0	309,0	18,8	76,7		
	V.	12,1	29,0	15,6		2,0	12,6		3,4	5,0	18,5	36,0	1,6	0,2	0,6	13,7	0,7	38,7	4,1	5,0	31,4	23,6	5,2	4,1	0,8	43,0	17,5	19,3	1,8	0,2	2,0	0,3	0,2		0,3		14,5	1,0	1,6	5,1	22,5	2,5	0,8	0,2	0,5	0,9		2,0	3,2	1,3		12,7	18,5	1,3	20,2		
Terebellidæ	A.								4,2													0,5				1,0						3,3																				
	V.								0,7													4,6				0,1						0,2				7,0							4,0								
Aphrodite aculeata	A.		1,0													1,0																				1,1							0,7								
	V.		13,8													4,8																								1,0												
Nereis var.	A.	47,8	38,0	20,0	16,0	58,0	60,0	70,0	46,5	70,0	71,0	33,0	27,0	23,0	58,0	85,0	60,0	50,0	42,8	40,0	87,7	60,1	43,2	63,7	37,0	59,0	70,7	59,9	27,7	48,0	67,8	13,5	6,7	18,3	23,1	10,0	31,0	30,0	8,0	39,1	32,0	80,0	38,0	38,0	55,0	35,0	12,0	42,5	47,5	12,5	32,5	49,0	30,0	8,4	28,4	13,1	1,7
	V.	5,2	6,1	1,8	1,2	2,2	3,4	7,6	5,8	8,3	8,0	3,2	1,4	0,8	1,9	3,6	2,3	4,0	9,6	2,3	4,8	4,0	3,3	3,7	1,7	5,2	7,2	3,5	1,4	2,3	4,5	0,3	0,7	1,7	2,2	5,5	1,6	2,1	0,6	4,0	3,6	6,9	3,8	3,2	2,6	4,1	1,1	13,0	4,0	1,8	32,5	4,1	2,2	1,1	3,8	2,2	1,2
Pinnotheres pisum	A.	55,6	15,0	12,0	12,0	4,0	52,0	6,0	38,2	12,0	156,0	30,0		24,0		44,0		31,0	14,1	10,0	3,8	20,9	11,4	10,0	1,0	28,0	105,0	106,4	6,7	22,2	43,2	1,7	10,7	1,7		1,7	1,0	1,0	1,0	8,7	37,0	4,0	8,0	3,0	2,0	4,0	2,0	5,0	30,0	5,0		0,0	34,0		30,0	0,7	
	V.	1,9	0,5	0,4	0,4	0,2	0,8	0,2	3,0	0,7	7,9	1,8		0,5		0,8		0,7	0,7	0,3	0,1	0,8	0,3	0,2		0,3	5,3	1,0		0,1	0,7		0,6	0,2		0,2	0,2	0,1	0,2	0,3	1,4	1,0	0,5					0,5	0,4		2,0	0,7		
Veneridæ	A.										29,0	194,0				2,0				48,8								120,0					1,7	1,7	1,7					5,0																
	V.										10,3	99,1				0,1				3,8								15,3						0,2	0,2					0,8																
Buccinum undatum	A.		1,0			2,0			0,0	1,0	3,0	1,0				1,0	1,0	1,0	2,6											1,1																										
	V.		0,0			1,0			4,1	2,0	37,0	9,0				14,3	10,5	2,8	7,5											0,3																										
Nassa reticulata	A.	2,0	2,0		2,0					4,0	1,0								4,1			0,0	0,0			1,0	0,7	0,0	1,1	1,1	2,2	8,2	1,7		3,2		4,0	1,0	1,0	2,0	1,0		2,6		1,0		3,0	4,0	5,0	2,5	2,5		6,0	7,0	8,3	10,7	10,0	8,2
	V.	3,0	1,0		3,2					4,2	1,1								3,1			0,2	2,5			1,2	0,7	1,2	1,9	0,9	2,1	5,2	1,7		4,2		4,1	1,6	1,1	1,7	2,5		0,2	0,7		4,9	5,0	4,0	3,2	2,5		4,7	7,1	1,1	11,2	5,5	5,0
Nassa pygmæa	A.		0,0	144,0	18,0	10,0	10,0	6,0	0,8		24,0	37,0	21,0	8,0	25,0	22,0	4,0	4,0		45,0	3,8	2,7	2,3	1,5		3,0		29,1	21,1	0,7	7,8							1,0			0,0	2,0	3,0	11,0	11,0				2,0							
	V.		0,0	4,0	1,0	0,6	1,0	0,0			1,2	2,1	0,8	0,5	1,2	1,1	0,2	0,2		4,0	0,5	0,2	0,1	0,1		0,2		1,6	1,2	0,1	0,6							0,1			0,0	0,2	0,1	0,3	0,4				0,2							
Ophioglypha texturata	A.	37,0	12,0	20,0	2,0	4,0	4,0	8,0	35,2	42,0	77,0	61,0	54,0	35,0	30,0	33,0	49,0	65,0	60,0	77,5	41,0	52,3	52,2	39,5	40,0	31,0	30,7	61,8	22,2	27,5	23,2	23,2	18,3	30,0	28,2	20,0	53,0	55,0	62,0	67,0	115,0	32,0	52,0	34,0	55,0	30,0	28,0	17,5	35,0	52,5	22,5	59,0	48,0		1,7	0,7	3,2
	V.	8,0	19,5	8,1	0,1	1,0	3,0	2,1	10,0	7,2	23,2	15,2	9,0	5,6	6,1	0,0	7,5	9,2	10,0	13,5	7,1	7,7	8,0	7,5	7,3	7,6	7,0	19,1	9,2	11,1	11,2	3,2	5,8	12,2	9,0	5,2	4,7	9,8	6,1	6,8	15,1	4,0	0,1	4,5	8,0	6,2	7,0	3,0	8,0	7,5	5,2	5,7	4,5		0,2	1,3	1,3
Asterias rubens	A.	1,1	1,0				2,0	2,0			1,0					1,0			0,5	0,9	0,5	1,0				1,7				1,1	1,7	0,7	1,7			1,0	2,0	1,0	0,4				1,0	1,0	1,0	2,0	2,5		7,5	2,5							
	V.	0,7	1,0				0,6	33,5			0,1				53,5				3,2			0,1	3,5	0,2	32,0		33,5				0,3	1,0	8,8	0,5	3,0		0,1	3,6	0,2	2,4			3,6	0,1	0,8	10,0	3,5		59,0	17,0	18,5	?					
Echinus miliaris	A.		1,0								2,0		1,0			1,0				0,5	0,0		1,5							2,2	5,6															2,5								
	V.		0,1								0,1	?				0,8		0,4		1,0	1,0		3,3							0,8	10,9					1,0		2,0							1,5								

*) Cardium sp.

*) Mya sp.
**) Cardium sp.

*) Mya sp.
**) Cardium sp.

Tab. V. Breeding-years in the Limfjord.

(Number of specimens of the 0-group per sq. m.)

a. Nucula nitida.

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Nissum Bredning			446	> 156	> 196	> 206	?	> 52	ca. 200	?
Lavbjerg Bredning					5 – 10			ca. 30	10 – 20	
Kaas Bredning-Sallingsund					30 – 40	40		10	45	54
Livø Bredning						7		50	60	48
Round Venø						35		15	?	
Næs Sund-Jegindø								Traces	Traces	
Visby Bredning								Traces	Traces	
Thisted Bredning			8 – 10	30	20	10	41	22	ca. 10?	10 ?
Fur Sund-Risgaards Bredning						22		15	3?	
Lovns Bredning								0	0	
Skive Fjord								0	0	

b. Abra alba.

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Nissum Bredning			0	> 28	> 112	> 112	Traces	Traces	> 17	
Lavbjerg Bredning					> 30			> 34	> 146	
Kaas Bredning-Sallingsund					75	90		12	195	120
Livø Bredning			> 22			> 29		387	151	46
Round Venø		267				550		9	100	
Næs Sund-Jegindø								45	15	
Visby Bredning								218	0	
Thisted Bredning			84	8	71	Traces	164	324	19	265
Fur Sund-Risgaards Bredning					24	Traces		80	ca. 200	
Lovns Bredning			219					805	0	
Skive Fjord								260	0	

c. Pectinaria.

	1908.	1909.	1910	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Nissum Bredning			> 39	> 53	> 105	> 29	> 5	> 19	> 25	
Lavbjerg Bredning		> 58			> 107			> 174	> 98	
Kaas Bredning-Sallingsund .					126	200		29	133	356
Livø Bredning						78		563	15	367
Round Venø.....		103				110		15	12	
Næs Sund-Jegindø.....								3	2	
Visby Bredning								238	3	
Thisted Bredning.....				90	40	215	20	99	10	171
Fur Sund-Risgaards Bredning						273		30	9	
Lovns Bredning.....			369					76	0	
Skive Fjord.....								7	2	

d. Solen pellucidus.

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Nissum Bredning			> 17	> 20	> 11	> 18	0	0	0	
Lavbjerg Bredning		> 56			> 10			> 6	> 16	
Kaas Bredning-Sallingsund .		724	?	57	57	87		0	20	1148
Livø-Løgstør Bredning.....		72			10	50	(10)	186	50	668
Round Venø.		1716				332		0	12	
Næs Sund-Jegindø								2	5	
Visby Bredning								6	3	
Thisted Bredning.....		38	Traces	226	60	50	60	6	Traces	242
Fur Sund-Risgaards Bredning		156			20	80	50	20	Traces	
Lovns Bredning.....			187					0	0	
Skive Fjord.....		20						7	5	

e. Corbula gibba.

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.
Nissum Bredning				Spor	75	40	1000–1500	Traces	Traces	Tracee
Lavbjerg Bredning			225	0	93	190	ca. 1100	ca. 800	62	40 - 50
Kaas Bredning-Sallingsund .	Traces	Traces	ca 1000	85	450	200	1500	570	87	95
Livø Bredning	94	55	234	40	45	12	146	66	23	29
Round Venø.....					13	11	403	45	150	75
Næs Sund-Jegindø.....							Traces	Traces	0	0
Visby Bredning							Traces		> 5	0
Thisted Bredning.....					155	0	4	7	5	0
Fur Sund-Risgaards Bredning					7	159	290	116	14	4
Lovns Bredning.....					11	69	250	10	11	0
Skive Fjord.....						126	440	0		0

f. Mya truncata.

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.
Nissum Bredning	is not found									
Lavbjerg Bredning	is not found									
Kaas Bredning-Sallingsund .			2 ?			9				2
Livø Bredning			25 ?				0		10	2
Round Venø.....			2 ?				0		1	0
Næs Sund-Jegindø.....									2	0
Visby Bredning									35	0
Thisted Bredning.....	+				0	0	2	1	67	1
Fur Sund-Risgaards Bredning			30 ?				0	0	6	0
Lovns Bredning.....	+ ?			0					30	0
Skive Fjord.....									10	0

Tab. VI. Temperature of the surface water at 8 o'clock a. m.

Average per Month.

		January.	February.	Marchs.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1907	Oddesund	0,2	÷ 0,8	2,5	6,2	10,0	13,1	15,1	13,9	12,1	11,3	5,6	2,4
	Aalborg	÷ 0,4	÷ 1,2	1,8	6,0	10,5	13,6	16,1	14,0	12,4	11,6	6,0	1,2
1908	Oddesund	÷ 0,1	1,8	0,8	5,3	10,1	15,6	17,1	15,5	13,1	10,6	4,6	3,3
	Aalborg	÷ 0,8	1,0	0,6	5,2	10,1	15,0	18,8	16,7	13,1	10,9	3,5	2,9
1909	Oddesund	1,7	÷ 0,6	÷ 0,6	4,7	9,1	13,6	15,4	14,7	13,1	11,1	4,7	1,7
	Aalborg	÷ 0,5	÷ 1,3	÷ 1,0	4,6	9,3	14,3	16,2	15,3	13,0	10,8	3,4	0,6
1910	Oddesund	1,4	0,3	3,5	6,5	11,9	17,2	18,1	17,0	14,6	10,4	3,9	2,1
	Aalborg	0,5	÷ 0,2	3,2	6,7	11,6	17,0	17,8	17,3	14,2	10,4	3,2	1,9
1911	Oddesund	1,9	1,8	2,5	5,7	12,8	15,6	16,4	18,1	14,5	9,1	6,1	3,2
	Aalborg	1,0	0,7	2,6	6,0	12,8	16,5	16,7	19,1	14,1	9,1	5,0	2,5
1912	Oddesund	÷ 0,1	÷ 1,1	3,2	6,3	10,3	13,5	18,2	15,7	11,8	8,7	4,6	3,9
	Aalborg	÷ 0,4	÷ 1,1	2,9	5,8	10,9	14,4	18,8	15,8	12,2	8,0	3,4	3,0
1913	Oddesund	1,4	0,9	3,2	6,0	11,4	14,7	16,5	16,0	14,4	9,5	7,7	4,9
	Aalborg	0,9	0,1	2,7	6,4	12,0	15,0	17,3	16,2	14,7	9,6	6,8	3,2
1914	Oddesund	0,3	3,4	3,3	7,5	10,6	15,6	19,0	17,8	14,8	9,2	5,2	3,5
	Aalborg	÷ 0,9	2,9	2,5	7,6	11,5	16,1	20,0	18,1	14,4	9,0	4,3	3,0
1915	Oddesund	0,2	0,0	1,4	5,9	10,6	14,5	15,5	16,1	13,9	8,2	3,4	0,2
	Aalborg	÷ 0,8	÷ 0,7	1,1	5,8	10,5	15,1	16,0	16,7	13,7	8,5	2,6	÷ 1,0
1916	Oddesund	2,7	1,6	0,4	5,6	10,9	12,3	16,8	15,7	13,1	8,7	6,4	2,8
	Aalborg	1,1	0,4	÷ 0,2	6,1	11,7	13,0	17,4	15,8	13,0	8,0	5,8	2,6
1917	Oddesund	0,5	—	÷ 0,8	3,2	10,1	17,2	17,5	18,1	14,0	9,1	5,7	2,8
	Aalborg	÷ 0,9	÷ 1,1	÷ 1,1	3,3	10,4	17,2	17,8	18,2	13,7	8,1	4,6	1,3

Our Gobies (Gobiidæ).

From the Egg to the Adult Stages

(With 3 Plates)

by

C. G. Joh. Petersen.

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Introduction.

It may seem strange, that I am already again dealing with the biology and the classification of our gobies, it being only 2 years since I discussed this matter in the report XXIV of the station; but so much that is new has been added on both scores, that it is necessary. I then only knew the development of *Gobius niger*, *Gobius ruthensparri* and the *Gobius microps—minutus* type; later on I have learnt that this last mentioned group consists of 3 well separated species, and I have moreover found the development of 3 other, "less frequent" species, so that now all our 8 species of *gobiidæ* are known more or less well. A 9th species *Gobius jeffreysi*, which is said to have been taken by "Lille Middelgrund" in the eastern Kattegat off Varberg, I have not seen at all.

About the facts mentioned in the earlier Report XXIV, after these later studies I have only to remark that in the summary group *Gobius microps—minutus* the young of *pictus* have also been included, Figs. 10 and 11 Pl. I. belong to this species. True *Gobius minutus* have not at all been pictured there, but Figs. 7—9 and 12 all belong to *Gobius microps*. Figs. 14 and 15 Pl. I. belong, I suppose, as indicated to *Gobius ruthensparri*, but they have not been accurately enough described; these stages are still difficult to distinguish from *Gobius minutus* and *Gobius pictus*.

At a certain stage of these investigations, I believed that a little fish of 5 mm. length, which is only seldom found in our collections (Pl. II. Fig. 22), was a young of *Aphya*, whose younger stages under c. 10 mm. I am still without; but the find of the bigger fish of 8 mm. pictured on Pl. II. Fig. 23, of whom several specimens are now before us, showed me, that it belongs to *Ctenolabrus rupestris*. The little fish of 5 mm. has namely, with fresh material, proved to have no swim bladder, which all our gobies have. Its pigmental spots show such exact conformity with the greater one of 8 mm, which has the same number of vertebræ as *Ctenolabrus*, viz. 33, that no doubt can be uttered about its determination as such. On this subject I shall not, however, enter into details.

In the following I shall try briefly to describe, especially with reference to the plates, the best specific marks of all our 8 gobies, as far as possible from the newly hatched to the adult stages; but first I must remark, that it is not always

easy in every stage to distinguish between all the species, and it is of no use trying to determine badly preserved fish of the youger stages; the best is to have good series preserved in weak formaldehyde, if the determination is to be successful. The excellent working conditions onboard the transport boat with its well communicating with the sea, in which many of these young fishes immigrate and may be caught and laid under the miscroscope alive, have helped much towards their determination; but without the skill, which the assistant of the station cand. mag. H. Blegvad, who is constantly onboard, has acquired in drawing these animals, I should have been badly off in the investigations, for the fish must be drawn at the moment it is caught, else it cannot be done. In no single investigation have I spent so much time and had so much difficulty as in this, and I shudder to think that similar investigations must some day be executed in countries where many more species of gobies live than with us; just because we have only 5 species, it has been possible to carry through the investigation. Perhaps the accomplishment of this may be of some importance to others as an orientation in the remarkable transformations which take place in the appearance of these fish from hatching to the adult stages.

It is usual in such works to mention the material of collected animals; but here there have been no limits to the quantity of material, it having been possible to fish unbounded quantities of gobies, especially of the younger ones by means of the steamer and the boats of the station during the summer and the autumn; in thousands they have been fished and as a rule after examination thrown out again; it is especially the young of the species *Gobius ruthensparri, minutus* and *pictus,* which have appeared in the plant region in such innumerable quantities in the Great Belt in the young fish trawl; along the shores at a depth of a few feet countless numbers of *Gobius microps,* grown up and young ones have also been caught. Large amounts of *Aphya* have been caught in young fish trawl down to a length of 8—10 mm., but never any beyond this length. Of *Crystallogobius* considerably fewer have been caught, and only occasionally, but by means of plankton nets also the smaller young have been brought up in less amounts. A lot of grown up *Gobius niger* are caught in common fishing gears and its young may be fished in certain limited localities, at times in scores, with young fish trawl, but it is far more local than the other species and only occurs a short time of the year. I looked for this species in wain for a long time, and my want of knowledge of it was the real first cause of the whole investigation.

Only *Lebetus* is comparatively rare in the Great Belt; the grown up specimens of this species are as yet only known to the number of 3—4 specimens from Denmark, but the young ones are more frequent. In the well of the station the small young might be found in August and later on in 1917 singly, and with the young fish trawl they might be fished, singly or some few specimens, fairly often at the bottom at a depth of c. 18—20 m. in the Great Belt; buth they are only with great difficulty distinguished from small, black pieces of decaying Zostera; at Hesselø c. 20 specimens were taken in August 1918.

I. On the Determination of the Adult and the Half-grown Stages.

To facilitate the determination of our gobies, some of the most obvious specific characters of gobies in the adult or yet half-grown stages will be mentioned here.

Aphya minuta Risso is elongate, transparent with 12—13 rays in the 2nd dorsal fin; 13—14 rays in the anal fin; 27 vertebræ. Plate III, Fig. 6.

Crystallogobius linearis Düb. Koren is elongate, transparent with 19—20 rays in the 2nd dorsal fin, 21—22 rays in the anal fin. 29—30—31 vertebræ. Plate III, Fig. 5.

*Lebetus scorpioïdes**) has very peculiar designs of colour on the body, and a long unpigmented and colourless portion on the hindmost part of the tail. The abdominal fins are not joined into a funnel. Big scales, but few rows of scales. In the first dorsal fin 6, in the 2nd dorsal fin 8—9, in the anal fin 6—8 rays. With us it has 25—26 vertebræ. Fage 1918 mentions 27—28 vertebræ. Plate III, Fig. 4.

Gobius niger is big, very dark coloured; with slight distance between the dorsal fins; the 2nd dorsal fin extends far out on to the tail, and according to Holt this fin has 12—13—14 rays; in the anal fin there are 11—12—13 rays;

*) Though R. Collett already in 1896 expressed his doubts as to the advisability of retaining the generic name *Lebetus* for the two species *orca* and *scorpioïdes*, which name was given to them by Winther in 1877—78, I cannot however but think it right to retain it for them. Though Collett is of opinion, that all transitions can be found between gobies with the abdominal fins joined in front, and species that have not this foremost joining skin, which transforms the abdominal fins into a funnel, I must however, i. a. as long as such transitions are not actually found, but also more particularly because the young of *Lebetus scorpioïdes* are so different from the other young gobies, maintain this generic name at any rate for *scorpioïdes;* I do not know *orca* from autopsy. F. A. Smitt 1899 in a short systematical disposition of the European gobies refers *Lebetus scorpioïdes* to a special group, by which „Cheek (distance from the hind end of the maxillary to the hind margin of the preopercle) longer than the postorbital part of the head".

The pigment series in the dorsal fins are nearly parallel to the back of the fish. (Plate I, Fig. 22 and Plate I Report XXIV, Fig. 6). The number of vertebræ is almost always 28; 27 and 29 have been found. The scales extend far forward and is found on the throat. Length ca. 15 cm.

The subjoined table of the number of rays in the 2nd dorsal fin and in the anal fin as also of the number of vertebræ of the 4 species *Gobius pictus, microps, minutus* and *ruthensparri* is based upon a material of either transparent specimens or coloured and prepared skeletons of specimens, which had previously been accurately determined by means of other marks. The table has been worked out by cand. mag. H. Blegvad and gives a very comprehensive view of the facts. The specimens all originate from the Great Belt; if perhaps the examination of still more specimens would have given a still greater overlapping of the figures, yet these here given speak plainly enough. *Gobius minutus* nearly always has 11 or 12 rays in the 2nd dorsal fin and the anal fin. *Gobius microps* and *pictus* always have 10 or 9. The number of vertebræ of *Gobius pictus* mainly lies at 30, of *Gobius microps* at 31, and of *Gobius minutus* at 33. These 3 species may therefore nearly always be distinguished from each other by the aid of these figures alone; the figures of *Gobius ruthensparri* often work out so that they fill up the intervals between *Gobius microps—pictus* on one side and *Gobius minutus* on the other; it must be sorted out first.

Number of finrays and vertebræ in 4 species of *Gobius*.
Kerteminde to Lundeborg 1917.

Gobius		No. of specimens examined			
		pictus	*microps*	*minutus*	*ruthensparri*
No. of rays in the 2nd dorsal fin	9	2	5	.....	.....
	10	**23**	**20**	1	**21**
	11	.....	.....	**12**	4
	12	.....	.....	**12**	.....
No. of rays in the anal fin	9	2	10	.....	1
	10	**23**	**15**	.....	**19**
	11	.....	.....	8	5
	12	.....	.....	**17**	.....
No. of vertebræ	29	(1)	.....	.....	.....
	30	**25**	3	.....	1
	31	.....	**19**	(1)	6
	32	.....	3	3	**18**
	33	.....	.....	**20**	.....
	34	.....	.....	2	.....

Gobius ruthensparri is easily recognisable. The distance above between the eyes very great; the eyes are turned outward to the sides, not slanting upward

as in the other gobies. The first dorsal fin has almost always 7 rays, sometimes 8; our other *Gobius* species have usually only 6 rays in this fin. Big, symmetrical*) black double-spot at the caudal pedunde. Length 6—7 cm. See here Plate I, Fig. 19 and Plate I, Fig. 18 in Report XXIV.

Gobius pictus. At the caudal peduncle (Plate III, Fig. 3) a black double spot, one part of which (nearly symmetrical) is situated in the middle of the tail itself, the other part is not in the middle of the base of the tail fin, but somewhat below its median line; between this double spot and the anus 3 big, double spots with sharp contours, the hindmost of which spots in the young may sometimes be triple. Below the foremost edge of the 1st dorsal fin is a black irregular design across the body. The first dorsal fin in the adults has below 2 rows of velvet black roundish spots; the lower row has 4, the upper 6 spots; a 7th spot is sometimes situated a little higher, the spots are on the skin of the fin. The 2nd dorsal fin in the fullgrown specimens has also 2 rows of velvet black spots. The lower row of spots in the dorsal fins is not found through the whole length of the fin; on account of its behind-pointing, slanting position the row then joins the body and ceases. Similar traces are found in *Gobius microps* and *minutus,* but rows of velvet black spots they never have. Lighter saddle — like spots are often found along the back of the fish likewise as in *Gobius ruthensparri,* but they also may be found in other species. The eyes are big and near to each other. The ripe males have an equipment of warts on the pectoral fins. These warts have only been observed in a few Danish specimens; as a rule they are too young to have them; but in a few specimens from the northernmost Kattegat they are found. In Report XXIV I have mentioned these warts, and now I can point out, that they are of the same nature as the sense-organs, which are found in the skin of all gobies; they have already been described by Winther 1874 in *Gobius niger,* and Fage attaches to them an exceedingly great systematic importance. Meanwhile their appearance is so variable from the young to the adult stages, that they are only of little importance to my following exposition of the development of the gobies; in the adult stages this, I am sure, is quite different, which the equipment of the pectoral fins in *Gobius pictus* shows; no other Danish goby has anything like this. Length 5,5 cm.

Gobius minutus (Pl. III, Fig. 2) has a smaller, often **T** formed double peduncular spot reminding one of the spot in *Gobius pictus;* but there are 5—6 round, grayish not double spots, some of them bigger, some of them smaller, between the peduncular spot and anus; the body is more lengthy than in *pictus* and *microps.* The scales in the adult stages extend out on to the anterior part of the first dorsal fin. The edges of the scales are distinctly visible, being black pigmented. Length c. 8—9 cm.

Gobius microps (Pl. III, Fig. 1) has no distinct double spot on the caudal peduncle, but when younger a dark, perpendicular stripe along it from top to

*) By symmetrical is meant that the spot may be divided horizontally in two symmetrical parts.

bottom. The 5—6—7 spots between the base of the tail and anus are more or less different and indistinct. The pigmentation in this species does not follow the edges of the scales as much as is the case in *pictus* and especially in *minutus;* the spots therefore have less sharp contours. The species when younger gives a much darker impression than the other two; *pictus* is the lightest, the black spots excepted. From the base of the upper pectoral fins rays two dark groups of pigment take their origin, one of them running along the basis of the pectoral fin, the other on the very rays; in *pictus* and *minutus* traces of this however are found in older specimens. The scales only extend to the posterior edge of the first dorsal fin. Length c. 5 cm.

On the first dorsal fin a dark spot may be found in *microps* and *minutus* in the living ones it is of a light blue colour; it is situated in front of the 6th ray. *Gobius minutus* rarely has 7 rays instead of the usual 6 in the 1st dorsal fin, then there may be two black spots, one between the 5th and the 6th ray, another between the 6th and the 7th. Holt has already called attention to this rare case. In the breeding dress perpendicular stripes sometimes appear across the body of the fish in *minutus* and especially often in *microps;* the perpendicular fins likewise are often dark coloured, and their rays lengthened, the 2nd dorsal fin extending far out on to the tail, reminding of *Gobius niger.* The colours on the body may also be very sooty, veiling the usual pigmental distinctions between the species. The velvet black spots, however, in the dorsal fin of *Gobius pictus* are always sufficient to identify it.

In the beginning it was only reluctantly, that I arrived at the conviction, that these 3 species really are species. The determination by means of habitus alone in individual specimens may cause some difficulty, especially if they are in a less good state of preservation; but with large and good material, such difficulties will always disappear or not exist at all. The counting of vertebræ and fin rays has convinced me that in reality there exist 3 unities, species, even if there is some overlapping of the figures, and even knowing that the number of vertebræ also varies within the species. The way in which the numbers here vary, does not indicate that outer conditions produce the variety in 3 groups. A study of the young of these 3 species has furthermore shown that the young may be distinguished from each other in most stages even when they have just escaped from the egg.

As to their habits of life, these seem to be very different, *microps* living in low water in protected seas, *pictus* in more open water, but yet in the plant region; on the contrary *minutus* goes out to our greatest depths in the Kattegat, though it breeds at the open sandy shores.

I must regret, that I have for so many years overlooked the true relation between these 3 species; I have been led astray by recent authors, especially Heincke and Holt; the older Scandinavian ichthyologists Malm, Krøyer, Lilljeborg, Collett have known better.

Surely Heincke in 1880 has not at all known specimens of *Gobius pictus*; it is wanting, I suppose, in the Baltic; he therefore has not sufficient foundation to pronounce an opinion on it*).

He regards *microps* as a subspecies of *minutus*, being mature at a youuger age; – but he has not known the great difference between the young of these two species, nor the fact, that *microps* mostly has 31 vertebræ, *minutus* mostly 33, and that very seldom overlapping of the numbers of the rays in the 2nd dorsal fin and in the anal fin is found. We have not been able to show any overlapping with certainty.

Holt follows Heincke in this question but not with regard to *Gobius pictus*; this fish lives at the shores of England, and here it is distinguished as a true species though especially by means of its pigmentation. Holt as the first of all has mentioned the peculiarly pigmented, just hatched young of this species. Holt (in Report on the Sea and Inland Fisheries of Ireland for 1901. Pt. 2. 1903) has mentioned a number of countings of the rays in the dorsal and the anal fin in *Gobius microps-minutus;* his assistant Byrne has counted them. Byrne has kept the specimens separated from the various localities, and it is seen from the figures, that in many localities the numbers 11 and 12 almost entirely prevail, in others the numbers 9 and 10; only a few transitional stages are mentioned. These figures seem to me to indicate, that we have 2 species to deal with. It is not always easy to count the fin rays in the gobies, i. a. the fact seems to be disregarded by many investigators, that the last ray in the 2nd dorsal fin and in the anal fin is split to the base**); it may therefore easily be counted as two rays; H. Blegvad has always counted this split fin ray only as one, and as a rule also counted the interspinalia; they are not split.

Also in recent years this matter has been debated in England and France. E. G. Boulanger 1911 thus shows, that both *Gobius microps* and *Gobius minutus* live at Roskoff, that the first named has 9—10 rays in the 2nd dorsal fin and the anal fin, very seldom 11 in one of these fins, the other on the contrary has 11—12 rays. The first one has 40—52 rows of scales, the other 61—71; even in the otoliths the difference between the two species is said to be visible. He writes: »The two forms here discussed have been quite correctly separated and identified by Messrs. Holt and Byrne; the only point on which I cannot agree with them is with regard to the existence of connecting links, which the examination of a large materiel has failed to disclose«. Boulanger has also examined specimens of these species from Denmark, Norway, England and Belgium.

E. le Danois 1913 nevertheless regards *Gobius minutus, microps* and *pictus* as varieties of one species, and he adds a fourth, *Gobius guitelli,* which is charac-

*) Heincke's paper was published in Troschels Archiv für Naturgeschicte 1880 Bd. I; I see, that in a paper by E. Ballowitz 1913 pg. 533 distinction is now made in Heligoland between *Gobius pictus* and *Gobius minutus*; so they do not follow Heincke there; any proof of this however, I do not know from Heligoland.

**) A quite similar fact is found in our two *Callionymus-species.*

terised by having a blue spot in the first dorsal fin of the ♀; such a spot he thinks, otherwise only occurs in the ♂.

Louis Fage 1914 after Sanzo 1911—13 has made a close eximination of the dermal papillæ of the gobies after having treated the fishes with chromic acid; he thinks, and as it seems rightly, that the occurence of these sense-organs give us good specific characters, by the aid of which it is easily possible, for example to distinguish *Gobius minutus* from *Gobius microps*. I think myself, that I am able to see the same by treatment with chromic acid. It seems that Fage does not know that G. Winther's paper of 1874, I, deals with these organs, especially in *Gobius niger*. In 1917 I mentioned, that on the posterior side of the pectoral fins in the grown-up males *Gobius pictus* has a peculiar equipment of warts, which I then did not quite understand, only pointing out that it was characteristic of the pectoral fins of *Gobius pictus* ♂; now I see, that these warts are only the accustomed dermal sense-organs placed on the pectoral fins; and later on I have seen, that i. a. in the grown up *Aphya* they also are found on the caudal fin; they are easily seen without preparation on the fins by transmitted light; but a similar equipment of warts on the pectoral fins such as *Gobius pictus* has it, I have not found in our other gobies.

Fage's later investigations from 1918, especially founded on the study of the dermal sense-organs of the adults, support my above mentioned opinion, that all our 5 species of *Gobius* are true, well separated, species. Meanwhile I do not think it quite necessary to call attention in so high a degree to these, not always easily observed sense-organs, as so many other good characters are available for the separation of these species. L. c. pg. 71—73 Fage pictures and mentions a series of young fish, which he with some doubt refers to *Lebetus (Gobius) scorpioïdes*; they are so much like the specimens found by me, that I think without doubt that they belong at least to the genus *Lebetus*.

Furthermore it must here be mentioned, that F. A. Smitt 1899 in a short general view of the European species of *Gobius* refers *Gobius minutus* and *microps* to two different groups; in one group, to which *Gobius microps* belongs, the smallest height of the tail is more than 7,5 % of the length of the body without the caudal fin; in the group with *Gobius minutus* the tail has a smaller height than 7,5 % of the mentioned length. Here he has given figures for what I have seen directly with my eyes, and the figures seem to be correct.

II. On the Determination of the Young.

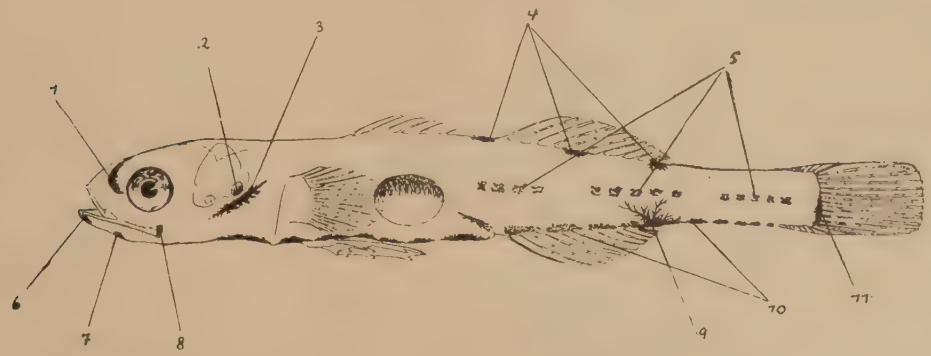
About the distinction of the young, only slightly pigmented and therefore more transparent stages, various information will later on be given for all our gobies, but one thing must be specially mentioned here, viz. the odd fact, that

Gobius niger, though our largest goby, much larger than all the others, passes into the bottom stage with long, well developed pectoral fin rays and much epidermal pigment already when it is 9—10 mm. long while the others, only the little *Lebetus scorpioïdes* excepted, are transformed much later; *Gobius minutus* gets well developed pectoral fin rays, though not of full length, when it is c. 17 mm. long, *Gobius pictus* when it is c. 15—17 mm. long and *Gobius microps* when c. 12—13 mm. long. Of remarkably short duration is also the development of *Gobius niger* into the bottom stage; that is presumably the reason why it has been so difficult to find these stages, and why they are comparatively few in number in the collections; the whole transformation takes place from the 9 mm. long, translucent, pelagic animal to the pigmented bottom stage of c. 10 mm., accordingly almost without length growth of the fish.

Before further mention of the younger stages of the gobies I shall make the following remarks. .

In these fishes various pigment spots or single chromatophores play a great part in the distinction of species, especially in the younger stages, as the case is in many other fishes. The nomenclature chosen for these spots and cromatophores will appear from the subjoined schematic figure.

Scheme of the Pigmentation of the Gobies.



1. Frontal spot.
2. Otolith with 1 black spot.
3. Median head chromatophore.
4. Upper caudal spots.
5. Vertebral pigmentation on the tail in 3 groups.
6. Lip spot.
7. Tongue Spot.
8. Lower jaw spot.
9. Specially developed chromatophore.
10. Lower caudal spot.
11. Spot on the caudal peduncle.

The tongue spot is a median, unpaired spot, in contradistinction to the paired spots on the lower jaw situated in the proximity. The likewise median head chromatophore is of specially great importance in the distinction of species; it is found in the quite young specimens of many species, but vanishes in some of them later on, in others it remaines till it is quite hidden by the outside dermal pigmentation, which in most species appears at the time, when the life at the

bottom begins. *Aphya* and *Crystallogobius,* living a more pelagic life, have always comparatively little dermal pigmentation, i. e., they remain clear as glass their whole life. The large, still pelagic stages of *Gobius minutus* are also clear as glass and are therefore to some extent habitually like the 2 mentioned species; but there are good distinguishing characters between them; which will be mentioned later on.

A. General View. (Plate I.)

Plate I may be considered as a summary plate for orientation in the determination of preserved material, which only keeps the black pigmentation, not the yellow, red and brown colours. It is then easily seen, that nearly all the young of our gobies can be determined alone by means of the shape of the body and the black pigmentation, some of them at the first glance, as for instance *Lebetus* with its many dermal, black chromatophores, its unpigmented hindmost part of the tail, its black pigment stripe along the median line of the tail, besides by means of its small size (Pl. I, Figs. 27—29). How its quite newborn larvae look, is not known.

Crystallogobius (Pl. I, Figs. 24—26) is known when quite young by its many dorsal spots, its peculiar frontal spot before the eye and a lip spot near the tip of the lower jaw. It lacks the median head chromatophore, lower jaw spot, and tongue spot. Later on nearly all this pigment disappears, but now the fish develops so many fin rays, that by the aid of them it can be distinguished from all other gobies.

Aphya's younger stages below 8—10 mm. are not known; the stages from this length upwards (Pl. I, Fig. 23) are known by their inconsiderable equipment of pigment on the head, having only one spot on the whole head, viz. a lower jaw spot and sometimes this also is wanting. The swim bladder is situated nearer to the centre of the body than in the *Gobius* species. The two long chromatophores at the lower end of the clavicula are besides characteristic of this species; yet they are somewhat like the corresponding chromatophores in *Crystallogobius,* but between c. 10—15 mm. this last named has its characteristic lip spot on the tip of the lower jaw and quite lacks pigment on the caudal fin, which *Ahya* has.

Gobius niger (Pl. I. Figs. 20—22) lacks the median head cromatophore, tongue-, lip- and lower jaw spot. Its pigment is collected in slightly ramified, deep black spots; such a spot on the dorsal side of the tail is very characteristic. About 9 mm. long it is almost like the adult ones.

Gobius microps (Pl. I, Figs. 1—5) before the pectoral fins are fully developed, always keeps its median head chromatophore, its lower jaw spot and tongue spot, together with the very much ramified chromatophore on the lower side of the tail; later on is developed, at a length of c. 12 mm., a black pigmented, perpendicular line on the caudal peduncle and is now much like the adult fish with its clumsy, short body. Its vertebral pigment on the tail is arranged in 3 groups like that of *Gobius minutus* (Pl. I, Figs. 6—10) and *pictus* (Pl. I, Figs. 11—15).

These two last named when newly hatched are easily distinguished from each other by pigmentation, likewise when they have developed the external vertebral pigment on the tail (*vide* later on); but in the intermediate stages it is impossible to distinguish them from each other without counting the vertebrae and the fin rays; the largest *minutus*, however, are known by their length alone.

Gobius ruthensparri (Pl. I, Figs. 16—19) is when newly hatched, difficult to distinguish from *minutus;* in the later stages they are also very much like *minutus* and *pictus*, yet the lower caudal row of chromatophores is usually unbroken and consists of very homogenous chromatophores while the row in the two just mentioned species is broken at the hindmost part of the anal fin. When it gets its vertebral pigment on the tail in one row, not in 3 groups, at a legth of c. 9 mm. it cannot, however, be confused with any other. (See Pl. I, Fig. 18).

B. More about the young of the 5 Species of Gobies (Pl. II).

Living or in formaldehyde newly preserved material.

a) The newly hatched and the slightly older stages. See plate II.

1) *Gobius microps.* Length c. 3—4 mm. Fig. 1.

Median head cromatophore, lower jaw spot, tongue spot. One of the lower caudal chromatophores is very prominent; one upper caudal chromatophore. The chromatophores black and lemon coloured, always very much ramified, so that they look grayish.

2) *Gobius minutus.* Length c. 3—4 mm. Fig. 4.

Median head chromatophore, lower jaw spot, this, however, may sometimes be wanting the first hours after hatching; tongue spot wanting. No very prominent lower caudal chromatophore, 1—2 black upper caudal chromatophores, and besides up to 4 yellow upper caudal chromatophores. Chromatophores black and reddish yellow.

3) *Gobius pictus.* Length 3—5 mm. Fig. 7.

Median head chromatophore, lower jaw spot, tongue spot. No very prominent lower caudal chromatophore, 3—5 upper caudal spots, all black and yellow. Chromatophores black and lemon coloured.

4) *Gobius ruthensparri.* Length 2,5—4 mm. Fig. 10.

Median head chromatophore, lower jaw spot, no tongue spot. A somewhat prominent chromatophore in the lower caudal row, 1—2 upper black caudal chromatophores together with several yellow ones. Chromatophores black and lemon coloured. Except in colour therefore it is very much like *Gobius minutus.*

5) *Gobius niger.* Length 2,8—4 mm. Fig. 13.

Quite without black pigment on the head and has at best a reddish yellow trace of median head chromatophore. The lower caudal spots are only little ramified and deep black; 3 spots are specially prominent, one below the yolk, one at the anus and one lower caudal spot. No or at best one upper black caudal chromatophore, besides one or two yellow ones.

b) The somewhat older stages, before the vertebral pigment appears, are in contradistinction to the younger stages, easily fished in silk nets and young fish trawl. See Plate II.

1) *Gobius microps.* Length 4—8 mm. Fig. 2.

Keeps its whole equipment of chromatophores. The very much ramified lower caudal spot is specially characteristic of this species. The colours are composed of black, very much branched chromatophores and lemon coloured, more diffuse spots.

2) *Gobius minutus.* Length c. 4—12 mm. Fig. 5.

Median head chromatophore disappeared. A black spot appears in the otoliths, at the length of 6 mm. The upper black caudal spots disappear, a yellow spot remains. Deep red chromatophores appear along the ventral side of the body, especially on the tail behind the anal fin; in the lower black caudal row there is a break behind the anal fin.

3) *Gobius pictus.* Length 5—8 mm. Fig. 8.

Is very much like *minutus*, but is often known by a particularly highly ramified, red and black lower caudal spot behind the anal fin; besides *pictus* is shorter. Can only be decidedly distinguished from *minutus* by means of the small number of vertebræ.

4) *Gobius ruthensparri.* Length 4—9 mm. Fig. 11.

The median head chromatophore and the upper black caudal spots disappear as in the two species previously mentioned. Many and closely placed black chromatophores along the ventral side of the body, accompanied by red chromatophores, which are only slightly ramified; as a rule no considerable break in the lower row of chromatophores along the tail; in these stages it is very much like *Gobius minutus* and *pictus*.

5) *Gobius niger.* Length 4—9 mm. Fig. 14.

The head is still without black chromatophores, a few in the region of the otoliths excepted. A very black, upper caudal spot, the swimbladder very black pigmented above. Has only black yellow colours, the red colours wanting.

c) Stages with vertebral pigment.

1) Already at the 9 mm. length *Gobius niger* has its vertebral pigment in an unbroken row along the vertebræ of the tail (Pl. I, Fig. 22) and then enters into the bottom stage with much dermal pigment; its number of fin rays and its whole appearance makes it easily recognisable from all our other gobies.

2) The second of our *Gobius* species, which has also an unbroken row of vertebral pigment along the tail, viz. *Gobius ruthensparri* (see Pl. II, Fig. 12) for a very long time continues its pelagic and later on half pelagic life, viz. right up to at least 12 mm., though as grown up fish it is much smaller than *Gobius niger*. The specimens of *Gobius ruthensparri* at these stages brilliantly black, red, brown and yellow coloured, are always easily distinguished from *Gobius niger* and indeed from all our other gobies.

3—5) *Gobius microps, minutus* and *pictus* have their vertebral pigment divi-

ded in 3 groups (Pl. I, Figs. 3, 8 and 13 and Pl. II Figs. 3, 6 and 9) between the anus and the caudal peduncle. *Gobius microps* for a long time retains its very much ramified, big, lower caudal chromatophore till it has got very much dermal pigment both on the back and on the head and is approaching the bottom stages, in which it is known by its clumsy anterior part of the body and its yellow and grey colours besides by its number of fin rays and vertebræ. Already at c. 11—12 mm. it enters into the bottom stage. *Gobius minutus* and *pictus* keep transparent far longer, right up to c. 17—18 mm., *pictus* is more brownish red than *minutus*, but this distinction is not easily made till the dermal pigment on the median line of the tail appears; in *pictus* it appears in the manner that the vertebral pigment sends branches through the median dissepiment of the fibrous tissue between the two groups of muscles, and the pigment then appears as horizontal lines, which are later on branched in the skin (Pl. 1, Figs. 13, 14 and 15 and Pl. II, Fig. 9); but in *minutus* the outside chromatophores are only found in the very skin, without any connection with the vertebral pigment, at any rate such a connection cannot be seen; the chromatophores therefore appear alone as ramified chromatophores in the skin (Pl. I, Figs. 8, 9 and 10 and Pl. II, Fig. 6). *Gobius pictus* begins to get dermal pigment on the tail, at a length of c. 12 mm., *minutus* only at 15 mm. Both these species have black and red (brown) chromatophores besides diffuse yellow colour at these stages.

C. More about the Young of Lebetus, Crystallogobius and Aphya.

Lebetus scorpioïdes (Pl. I, Figs. 27—29) has already at 3,5 mm., smaller stages I do not know, much black dermal pigment, with a black stripe of dermal pigment along the median line of the tail; it has median head chromatophore and lower jaw spot, but the posterior part of the tail and the tail fin are quite pigmentless, making it almost impossible to discover these animals; when living and lying quiet, they much resemble dark pieces of sea-weed. Besides black chromatophores the younger stages have diffused carmine red pigment on the lower half of the body. A specimen of 15 mm. length from Kerteminde, May 19th, 1904, depth 4 m., had 25 vertebræ. D I 6, D II 8, A 6 rays. In another I have found 26 vertebræ.

Crystallogobius linearis (Pl. II, Figs. 15—19) as quite young wants both the black median head spot, yet red pigment is present, tongue spot and lower jaw spot, but has a particular frontal spot anterior to the eye, and a lip spot on the tip of the lower jaw, besides many spots along the upper and the lower side of the body; nearly all this pigment is lost later on at 7—8 mm. length, except the spot on the tip of the lower jaw and a lower caudal spot; but other spots along the lower side of the tail are soon developed. At 9 mm. they may already be determined by their great number of 15 and 19 rays in the dorsal and the anal fin; for a long time they are without pigment in the hindmost part of the tail and in the tail fin. Number of vertebræ 29—30. Besides black chromatophores they

have, when younger, very much ramified, red chromatophores, especially along the lower side of the tail; one of these is recognised also in older specimens up to at least 11 mm. length.

Aphya minuta (Pl. II, Figs. 20—21) I only know down to c. 8—10 mm. length. They are as lengthy as *Crystallogobius* and are known, besides by the before mentioned marks, by the red chromatophores in the stomach region and 5—6 peculiar red stripes on the tail behind the anal fin. Yellow diffused and black pigment is found on the tail fin, and the smaller ones have yellow pigment at the hindmost part of the dorsal fin. The two peculiar, black chromatophores at the clavicula and the position of the swim bladder nearer to the centre of the body than in any other of our gobies are particularly good marks. Number of vertebræ 27. In these stages they have already at a length of c. 10—17 mm 11—12—13 rays in the anal and the dorsal fins; 1st dorsal fin is as yet only rudimentary.

III. Conclusion.

When I have spent so much time in the investigation of these small fishes, whose eggs I already studied the first year, 1890, in which the station was established, it is because they are found in such enormous multitudes in our Danish fjords and simply on this account enter into the recent valuation-investigations; but it is also because the station under the present conditions cannot take up investigations which demand much sailing with the steamer, and these investigations do not demand this. Furthermore it is unfortunate so often to meet fish and fish young in our gears, which we cannot determine with certainty; on this account alone this study is entitled; finally I have thought that further it might be of importance to follow the development of these fishes from the very first stages to the adult fish; for this development as a rule takes place in less time than a year; the real food fishes on the contrary need several, nay some of them many years, to reach the adult stage. Perhaps these small fishes, on account of their rapid development may help towards the solution of the great question, why the young some years are more numerous than in others. It remains to be seen if this hope will come true.

These above mentioned closing remarks were written a year ago; I have to add the following: During the many years in which I have been fishing in the Danish waters, I have, perhaps with a few exceptions in the northernmost Kattegat, never found really adult *Gobius pictus*; when in August 1917 my eyes were first opened to the fact, that its young were found in abundance in the Great Belt

in the autumn, I thought I had overlooked the adult ones during these years, and I supposed, that in the course of the winter and the spring of 1918 I should very easily find them here, when the young were grown up; but I have not found a single adult fish here; all the young disappeared in the course of the winter 1918, though they certainly are not migrating fishes more than for instance *Gobius ruthensparri;* and the young of the last mentioned were numerous enough and also the adult fish, during the whole winter and later on in 1918. We know, it is true, that the cod eats a great many of these fishes, in the winter half year, but I do not think it reasonable, that it should be able to eat up all the specimens of *Gobius pictus*. They might be fished by hundreds in the autumn 1917, with a small trawl, which was drawn after a little sailing boat for 10 minutes, so numerous were they. I must suppose that there are other reasons for the total disappearance of the young of this fish though the cod has also his part in it.

Now I was very anxious to see, whether the young would return in the summer of 1918 in the Great Belt; they did so in August, though not in such numbers as in 1917; it seems, as if it was only after periods with a northern current and a western wind, that they appeared, and therefore I supposed that they came from the north; a cruise in August 1918 with "Japetus Steenstrup" in the Kattegat to the Hesselø, — I dared not go farther away in the eastern Kattegat on account of the danger of mines, — showed, that here in the deepest water were enormous swarms of the young of *Gobius pictus* together with lots of young *Aphya* and some few young of *Lebetus;* besides there were found in this area of water *Pleurobrachia* and *Sagitta* which were also found in the Great Belt at the same time as the immigration of the young of *Gobius pictus* took place. I cannot but believe that the young of these 3 fish species as a rule come to us from the shores of Sweden and Norway, where the adult fish have been described and are known. The same will apply to *Crystallogobius;* of this species only some few and small specimens were found in 1918 (at Sejrø), but in 1917 it was more frequent and sometimes went down to the Great Belt. However, there is still a possibility that a portion of the young of *Gobius pictus* may come from the northern Kattegat, for this I have not been able to examine these last few years. From an early date I have in my collections of gobies altogether only one nearly full grown specimen of 4 cm. length from N. of Djursland, 8 m. depth, 24—7—1901, furthermore some rather big ones taken in June from Hirtsholmene and the northern side of Læsø; several of these had got the equipment of warts on the pectoral fins; *Gobius pictus* thus seems to be very rare, when full grown, at the shores of Denmark even in the northern Kattegat; for the present I must therefore believe that its young mainly immigrate from the Norwegian and Swedish shores. The matter should be more closely examined after the war; only now when we have learned to distinguish between the species is it possible to examine the biology of the gobies. *Aphya* is found also when adult with us in the Great Belt but so scattered that a real stock, I suppose, is out of the question.

It is no wonder, therefore, that it has been a very difficult task to find out the embryology of our 8 gobies, the adult of several species being not indigenous with us, at any rate not in our southern waters, and the distinction of species of several adults being as doubtful, as it has hitherto proved. In accordance with this I only know the eggs from autopsy, fixed on objects on the sea bottom, of *Gobius niger, microps, minutus* and *ruthensparri*, but I have never been able to find the eggs of the 4 other gobies.

Copenhagen, January 1919.

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Explanation of the Plates.

All the figures have been drawn by means of a drawing-prism.

Plate I.

Gobius microps.

Fig. 1. 3 mm., c. 24 hours old Hatched from egg. Slipshavn, Nyborg Fjord, 25–5–1918. — Type of the stages from newly hatched young to c. 4 mm. length.

Fig. 2. 8 mm., 31 vertebræ. At the pier of the Biological Station, Nyborg, 18–6–1918. – Type of the stages from c. 4–8 mm. length.

Fig. 3. 11 mm, Nyborg Fjord, from low water. August 1917. – Type of the stages from c. 8–12 mm. length.

Fig. 4. 14 mm., At the pier of the Biological Station, Nyborg, 1–9–1917. – With permanent rays in the pectoral fins.

Fig. 5. 21 mm., At the pier of the Biological Station, Nyborg, 5–9–1917. – Scales along the lower side of the body.

Gobius minutus.

Fig. 6. 3 mm, c. 24 hours old. Hatched from egg, laid by *Gobius minutus* in aquarium. Nyborg, 27–5–1918. – Type of the stages from newly hatched young to c. 4 mm. length.

Fig. 7. 12 mm, Hvidegrund, Nyborg Fjord, 6.–7. Sept. 1917. Type of the stages from c. 4–12 mm. length.

Fig. 8. 16 mm., East of Vresen's buoy, Great Belt, 29–8–1917. – Type of stages from c. 12—16 mm. length.

Fig. 9. 19 mm, North of Lundeborg, Great-Belt, 1–9–1917. – With permanent rays in the pectoral fins.

Fig. 10. 28 mm, The Bay of Kerteminde, off the harbour of Kerteminde, 18–8–1917. – Scales, except on the upper side of the body.

Gobius pictus.

Fig. 11. 3 mm., South of Hesselø, 26 m, 8–8–1918. – Type of the stages from c. 3–5 mm. length.

Fig. 12. 7 mm., South of Hesselø, 26 m, 8–8—1918. – Type of the stages from c. 5–9 mm. length,

Fig. 13. 15 mm., Off Lundeborg, Great Belt, 1–9–1917. – Type of the stages from c. 9–15 mm. length.

Fig. 14. 19 mm., Off Lundeborg, Great Belt, 1–9–1917. — With permanent rays in the pectoral fins.

Fig. 15. 22 mm., Off Lundeborg, Great Belt. 1–9–1917. – Scales along the lower side of the body.

Gobius ruthensparri.

Fig. 16. $2_{/6}$ mm., Some few hours old. Hatched from egg. Hvidegrund, Nyborg Fjord, 13–6–1918. – Type of the stages from newly hatched young to c. 4 mm. length.
Fig. 17. $8_{/5}$ mm., 31 or 32 vertebræ, Hvidegrund, Nyborg Fjord, 17–6–1918. – Type of the stages from c. 4–9 mm. length.
Fig. 18. 9 mm., Nyborg Fjord, September 1917. – Type of the stages from c. 9–12 mm. length.
Fig. 19. 15 mm., Nyborg Fjord, September 1917. – A few scales on the lower side of the tail, permanent rays in the pectoral fins.

Gobius niger.

Fig. 20. $2_{/8}$ mm., Some few hours old. Hatched from egg. Slipshavn, Nyborg Fjord, 13–6–1918. Type of the stages from newly hatched young to c. 4 mm. length.
Fig. 21. 9 mm, 28 vertebræ. From the well in the transport boat of the Biological Station, Nyborg, 19–7–1917. – Type of the stages from c. 4–9 mm. length.
Fig. 22. $9_{/5}$ mm, Nyborg Fjord, at the station, 31–7–1917. – Type of the stages from c. 9–11 mm. length. With permanent rays in the pectoral fins.

Aphya minuta.

Fig. 23. 10 mm, 27 vertebræ. Off the harbor of Kerteminde, 18–8–1917. Type of the stages from c. 10–20 mm. length.

Crystallogobius linearis.

Fig. 24. 4 mm., East of Vresen's buoy, Great Belt, 24 m, 20–9–1917.
Fig. 25. 9 mm., 30 vertebræ. East of Vresen's buoy, Great Belt, 24 m, 20–9–1917.
Fig. 26. $11_{/2}$ mm., 30 vertebræ. East of Vresen's buoy, Great belt, 24 m, 19–9–1917.

Lebetus scorpioïdes.

Fig. 27. $3_{/5}$ mm., East of Palegrund, Nyborg Fjord, 6–8–1917.
Fig. 28. $4_{/2}$ mm., East of Palegrund, Nyborg Fjord, 6–8–1917.
Fig. 29. $5_{/5}$ mm., 26 vertebræ, East of Vresen's buoy, Great Belt, 24 m, 19–9–1917.

Plate II.

Gobius microps.

Fig. 1. 3 mm., c. 24 hours old. Hatched from egg. Slipshavn, Nyborg Fjord, 25–5–1918.
Fig. 2. 8 mm., 31 vertebræ. At the pier of the Biological Station, Nyborg, 18–6–1918.
Fig. 3. 16 mm., 31 vertebræ. At the pier of the Biological Station, Nyborg, 27–8–1917.

Gobius minutus.

Fig. 4. 3 mm., c. 24 hours old. Hatched from egg, laid by *Gobius minutus* in aquarium. Nyborg, 27–5–1918.
Fig. 5. $11_{/5}$ mm., 34 vertebræ. Hvidegrund, Nyborg Fjord, 5–7–1918.
Fig. 6. 18 mm., 33 vertebræ. Hvidegrund, Nyborg Fjord, 30–8–1917.

Gobius pictus.

Fig. 7. 3 mm., South of Hesselø, 26 m., 8–8–1918.
Fig. 8. 7 mm., South of Hesselø, 26 m., 8–8–1918.
Fig. 9. 14 mm., Hvidegrund, Nyborg Fjord, 19–9–1918.

Gobius ruthensparri.

Fig. 10. $2_{,6}$ mm., Some few hours old. Hatched from egg. Hvidegrund, Nyborg Fjord, 13 - 6 - 1918.
Fig. 11. $8_{,5}$ mm., 31 or 32 vertebræ. Hvidegrund, Nyborg Fjord, 17 - 6 - 1918.
Fig. 12. 13 mm., Hvidegrund, Nyborg Fjord 21 - 9 - 1918.

Gobius niger.

Fig. 13. $2_{,8}$ mm., Some few hours old. Hatched from egg. Slipshavn, Nyborg Fjord, 13 - 6 - 1918.
Fig. 14. 9 mm., 28 vertebræ. From the well in the transport boat of the Biological Station, Nyborg, 19 - 7 - 1917.

Crystallogobius linearis.

Fig. 15. 4 mm., East of Vresen's buoy, Great Belt, 24 m., 20 - 9 - 1917.
Fig. 16. 5 mm., East of Vresen's buoy, Great Belt, 24 m., 19 - 9 - 1917.
Fig. 17. 6 mm., Deep channel East of Munkegrund at Samsø, 52 m, 7 - 8 - 1918.
Fig. 18. 9 mm., 30 vertebræ. East of Vresen's buoy, Great Belt, 24 m, 20 - 9 - 1917.
Fig. 19. $11_{,2}$ mm., 30 vertebræ. East of Vresen's buoy, Great Belt, 24 m, 19 - 9 - 1917.

Aphya minuta.

Fig. 20. 10 mm., 27 vertebræ. Off the harbor of Kerteminde, 18 - 8 - 1917.
Fig. 21. 17 mm., 27 vertebræ. East of Palegrund, Nyborg Fjord, 6 - 8 - 1917.

Ctenolabrus rupestris.

Fig. 22. 5 mm., From the well in the transport boat of the Biological Station, Nyborg, 16 - 8 - 1917.
Fig. 23. 8 mm., 33 or 34 vertebræ. S. W. of Schultz's ground, 41 m., 7 - 8 - 1918.

Plate III.

Fig. 1. *Gobius microps.* 30 mm., At the pier of the Biological Station, Nyborg, 18 - 9 - 1917.
Fig. 2. *Gobius minutus.* 48 mm., Nyborg Fjord, 13 - 11 - 1917.
Fig. 3. *Gobius pictus.* 30 mm., North of Lundeborg, Great Belt, 8 m, Zostera, 24 - 8 - 1917.
Fig. 4. *Lebetus scorpioïdes.* 16 mm., Anholt, May 1902.
Fig. 5. *Crystallogobius linearis.* 35 mm., East of Vresen's buoy, Great Belt, 24 m., 29 - 9 - 1917. – Still without permanent rays in the pectoral fins. The long ovaries extend far out into the tail.
Fig. 6. *Aphya minuta.* 36 mm,. Nyborg Fjord, 18 - 9 - 1917. – Still without permanent rays in the pectoral fins.

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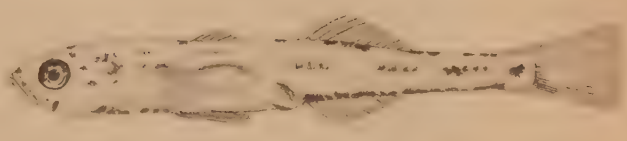

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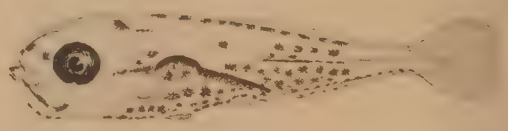

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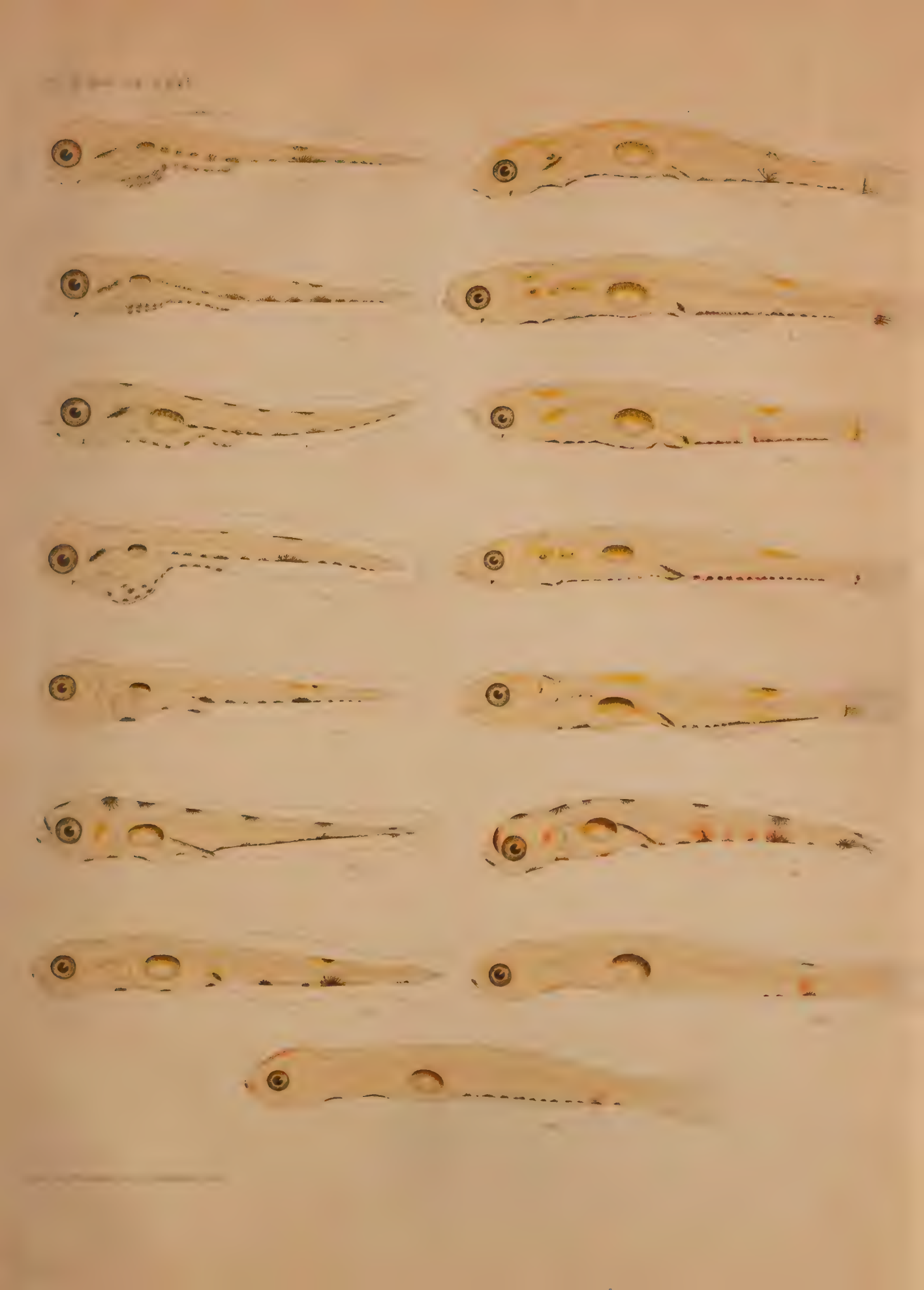
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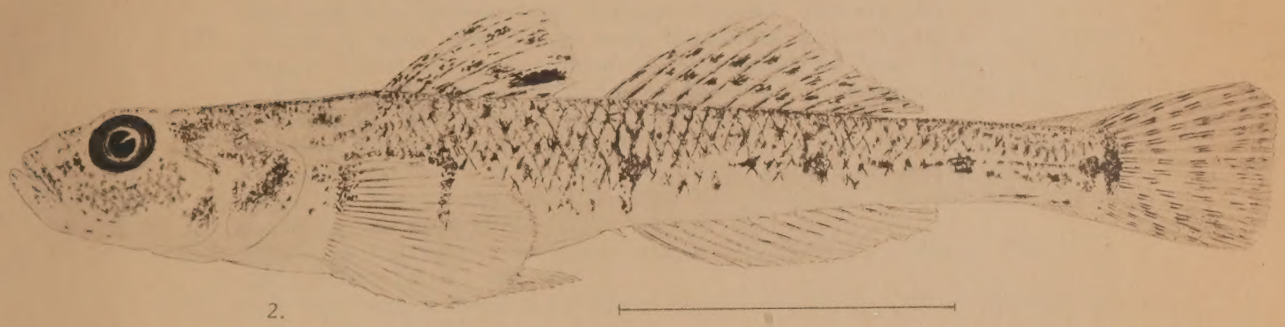

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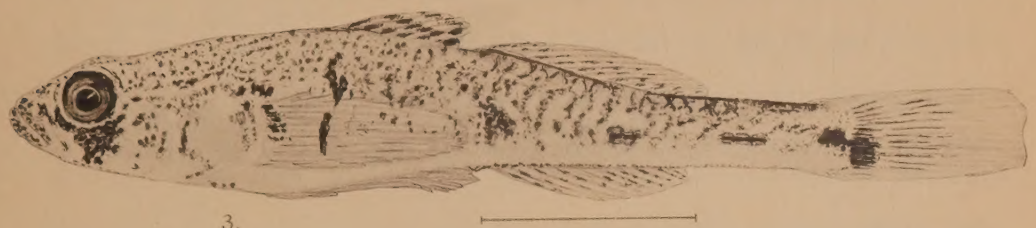

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IX. Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pg. With one Map.

X. Fortegnelse over Aalerusestader i Danmark etc. — Mindre Meddelelser. 1899 og 1900. 36 pg. Et farvetrykt Kort. (1900—01.)

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XI. I. Torskens Biologi i de danske Farvande. II. Om andre Torskefisk i vore Farvande. III. Nogle almindelige Betragtninger om Fredning, Lovgivning etc. IV. Ændringer og Forbedringer af Skovlvaad til zoologisk Brug. 44 pg. (1900—01.)

XI. 1. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alternations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pg.

XII. I. Hvor og under hvilke Forhold kunne Rødspættens Æg udvikle sig til Unger indenfor Skagen? 1 Kort. II. Smaahvarrernes (*Zeugopterus*-Slægtens) Unger. 1 Tavle. III. Kunne vi optage Konkurrencen med Udlandets Damptrawlere i vore Farvande udenfor det danske Søterritorium? 1902 og 1903. 36 pg. (1903—04.)

XII. I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus*. (With one Plate.) III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pg.

XIII. Fiskeæg og Fiskeyngel i de danske Farvande. (Undersøgelser i 1904 og tidligere Aar.) 1903 og 1904. 81 pg. (1904—05.)

XIII. Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pg.

XIV. I. Om Lysets Indflydelse paa Aalens Vandringer. II. Om Aalens Alder og Vækst. 1906. 39 pg. (1905—06.)

XIV. I. The Influence of Light on the Migrations of the Eel. II. Age and Rate of Growth of the Eel. 1906. 39 pg.

XV. Studier over Østersfiskeriet og Østersen i Limfjorden. Med et Kort, Temperaturkurver, 3 Tabeller og 2 Tekstfigurer. 1907. 70 pg. (1906—07.)

XV. I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pg.) 1908.

XVI. Aalegræssets (*Zostera marina's*) Vækstforhold og Udbredelse i vore Farvande. 1908. 61 pg. (1906—07.)

XVI. On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. (With 9 figures.) 1908. 62 pg.

XVII. Studier over Østersfiskeriet og Østersen i Limfjorden. 1908. 24 pg. (1906—07.)

XVII. II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pg.)

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